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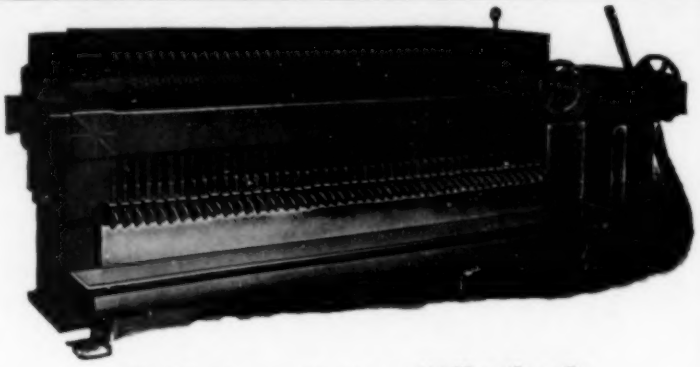

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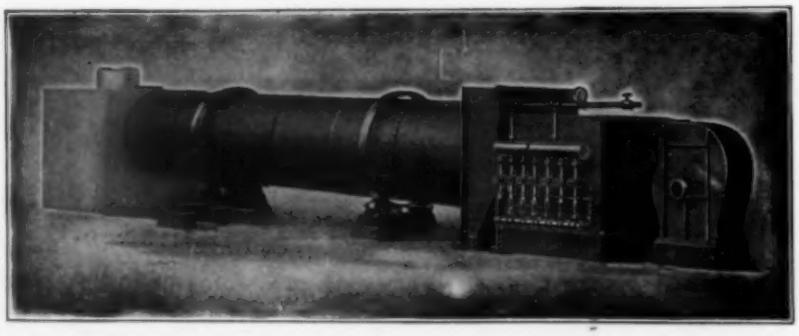

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City Gas and Modern Warfare

THE exigencies of war are likely to familiarize every domestic user of gas with one phase of our great chemical industry and its relation to modern combat. We refer to the recovery of toluol from city gas and its conversion into trinitrotoluol, TNT, the high-explosive of modern warfare. The shortage in this commodity, which has been recovered largely from by-product coke-oven gas, will be brought home to every user of city gas in this country before the campaign for its production is over. Gas consumers thus become vitally interested in the production of explosives, and in the end it is likely that they will profit by changes in gas standards which are otherwise desirable and which war is only hastening.

Two different standards exist for determining gas quality. Almost every city has adopted one, and some have both. There is the candle-power standard, which is now considered antiquated, being a relic of the days before the incandescent mantle was known. Opposed to this is the more modern and scientific heating-value standard which grades gas in terms of British thermal units. Now toluol and benzol are important factors in both the heating and lighting values of city gas. Hence the removal of these hydrocarbons, or particularly toluol, will reduce both the lighting and heating values below the standards prescribed in various cities. This has necessitated a revision of the standards already in effect by city ordinance, and in some cases has involved the consent of public service commissions.

From estimates made by the U. S. Bureau of Standards as to the influence of toluol recovery on gas quality it appears that candlepower is more seriously affected than heating-value by the removal of toluol. This suggests the elimination of the candlepower standard altogether and the substitution of a heating-value requirement; and since there are other reasons for abandoning the older standard in favor of the newer, the effect of the war is to hasten the adoption of an otherwise desirable practice.

Thus are peaceful pursuits modified by the requirements of war. Hitherto city gas has been just a convenient form of fuel to be had for the turning of a valve; suddenly it becomes an important source of a war necessity. That we have not always recovered toluol from city gas and thereby been prepared for the present emergency is due to economic conditions and not to lack of knowledge or ability. Like many other by-product industries which we have left to our European neighbors, toluol recovery has not appealed to us. It served us best in the gas where it was originally formed, and there was no good reason for taking it out. Technical industry is replete with similar instances.

The Dyestuff Association

THE Dyestuff Association of America has been duly organized and we wish it well. When those interested in the manufacture and sale of anything meet to consider the general welfare it is usual that preliminary negotiations have more to do with who shall guide than with who shall contribute. In this respect the participating manufacturers of dyestuffs and intermediates felt that their investments and interests required that only manufacturers should be members, while dealers might be associate members without voting power but with single representatives on leading committees. This was a wise provision, because in the dyestuff industry, while manufacturing and selling very properly go hand in hand, the economic problems have to do with manufacturing. The art of selling dyes and giving the proper service with sales is difficult and it has been to many a profitable undertaking, but it sinks into unimportance when compared with a well co-ordinated, native manufacturing industry.

Before the great war, dyestuffs were principally made in Germany and sold here, originally through German agencies; and even down to 1914 the selling was in good part under German control. It was a business replete with German traditions, being at once efficient and rotten. The bribery of dyers was an established custom. "They all did it," said an old dealer, "and the only difference in this connection between Americans and Germans who engaged in the practice was that the Americans knew it was wrong and the Germans didn't." The nomenclature of products still has the ear-marks of the undesirable sort of German *Kultur*. It is unconscionably ugly and devoid of all enlightenment or fancy except in so far as it was designed to deceive.

The association will now have to find itself. Able men with high ideals are earnestly interested. Reforms in pre-war selling practices are urgently needed. just as is the development in manufacturing. The tariff should be amended by the elimination of the joker that was inserted into the bill at the last moment whereby alizarine and indigo products were excepted from the specific duty; but when that is accomplished let us hope that the association will devote itself in the maximum to research and development and in the minimum to profits by acts of Congress. The start is auspicious.

Tendencies in Copper Milling

IT HAS been observed that there are prevailing styles in ore-dressing which change from time to time in accordance with ideas evolved through research and experiment. These changes may be abrupt, but are more often gradual and usually there is a transition period during which tendencies can be observed which later become established custom. Copper milling has been particularly responsive to progressive suggestions, and for that reason has been one of the most interesting branches of ore treatment.

The principal tendency observed in copper milling for some years past has been to eliminate stage-crushing and to devise flow-sheets producing no coarse concentrates. In this manner preliminary crushing by rolls followed by regrinding of jig tailings in edge-running mills is apparently being supplanted by a finer original reduction by disc crushers and tube or ball-mills. One notices a tendency for the trommel to be replaced by the impact or shaking screen. Mill men are also beginning to appreciate the necessity of adequate settling capacity to catch the last portions of mineral from spent water, and huge tanks for settling, thickening and de-watering are quite common.

Flotation is used on every hand, either as the main concentrating device, or as an expedient to recover mineral formerly lost in slimes and tailings. The beauty of simplicity seems to have been attained in some of the latest installations, where the flow-sheet consists of the four steps: crush, float, thicken, filter. This wonderful process has enabled the mill-man to produce a tailing extraordinarily low in value, the majority of these losses being of oxidized particles which will not float. He is therefore turning his attention to the task of recovering these last modicums of value—indeed, the outstanding problem in milling practice today seems to be to devise some economical and practicable method for handling ores which contain a mixture of copper oxides and sulphides. This problem is usually attacked by hydrometallurgy; sulphidizing flotation (as practiced at Hurley and elsewhere) may come under this head, since the oxide probably goes first into solution, even superficially, before being precipitated as a sulphide.

These tendencies in the mill are responsible for the increasingly large quantity of fine concentrates sent to the smelter, shipments often consisting of large tonnages of a sticky filter-cake containing upwards of 15 per cent of water. Many revisions in smelting equipment are due to this cause. Particularly in the roasting department, pan feeders are necessary to deliver a constant quantity of this wet material to the furnace. The large Herreshoff or Wedge furnace, or a modification of these styles, is now being installed almost exclusively, and in some cases supplanting the smaller McDougall roasters. The top of these furnaces is utilized as a preliminary drying hearth, while auxiliary heat is usually necessary to complete the roast. Separate coal-fired fire-boxes, powdered-fuel burners, and oil torches are each successfully used for this purpose. The ample drop-hole area afforded by the larger furnaces is also essential to prevent huge dusting losses when handling the extremely fine materials now so prevalent.

The Fuel Order

WE SHALL comment but briefly on the now famous fuel order of Dr. Garfield. It has received attention, respectful and otherwise, at the hands of editors throughout the country and has generally been condemned. We should not lose sight of the fact, however, that the great majority of the critics have not been handicapped by any personal knowledge of the underlying causes and have, therefore, been able to discuss the subject at length and without embarrassment. Our own impressions were gathered at an audience which Dr. Garfield gave to a small group of editors of McGraw-Hill engineering publications.

The fuel order was a military necessity. As such it is not susceptible of explanation in detail without disclosing information to the enemy. It was not designed primarily to save fuel, but to improve conditions in railroad transportation, the demoralization of which was the chief contributing factor to our difficulty. We have

not lacked fuel, but engines and cars with which to handle the freight. The same situation would have developed in some degree if there were no war. It is the urgency of the situation which impresses our lack upon us. The shortage of motive power and rolling stock is attributable, in turn, to the government's policy of the past few years which has resulted in starvation of the railroads. Failure to heed the railroads' requests for an income which would enable them to operate profitably and maintain their equipment in good condition left them unable to serve the country in its crisis.

To all this should be coupled the fact that, with coal in great quantity loaded in cars and standing on the tracks, the Fuel Administration was unable to get a priority order for shipments of fuel to the seaboard, while other favored commodities continued to arrive at coast ports and congest the terminals. This failure to observe a proper sequence in the receipt of coal and other products made it impossible to bunker the ships that were loaded and waiting to transport *materielle*.

The administration of our fuel resources has not been altogether satisfactory, but the trouble has been a lack of co-ordination at Washington—the same trouble, in fact, which is now being revealed, and we hope remedied, in other departments. Recall, for instance, the ill-advised price-fixing which was done hastily to forestall independent action by state governors, the immediate repudiation of the agreement by the Secretary of War, the consequent confusion among consumers and failure to lay in stocks anticipating a lower price, the refusal by Judge Lovett of a priority order on coal and the failure to observe a proper sequence in consignments of fuel and commodities to the seaboard—recall these and the railroad situation, and we can find ample reason for the fuel order. It was inevitable. The weather having been unfavorable to securing the best results from a weakened transportation system, we may expect other closing orders and embargoes on freight.

Too Little Railroad Regulation

NO, THERE is no misprint in the caption. If there is a mistake it is by the editor, not the printer. Most of the talk lately has been of "too much railroad regulation." Perhaps with a qualifying phrase the statement might be correct, that there has been too much regulation of its kind. What occurred was that legislation did not keep pace with the progress of events. The original Interstate Commerce Act, which passed its thirtieth birthday last year, was intended, and very properly, to make railroad charges uniform and eliminate the giving of rebates. That was quite necessary, but other things have since come to be necessary.

The theory of railroad regulation was correct; the application very faulty and altogether incomplete. The theory was that railroads were essential for the development of the country, that the business of the country depended largely upon the railroads, hence the federal government should regulate the railroads. The sugar question is quite a familiar one at this time. It is being regulated, but the public is not satisfied simply with the price being held down. It wants sugar. The price is one thing, the securing of the sugar another. The former is of no use without the latter.

In the case of the railroads only the price has been regulated. No effort has been made to see to it that the public is furnished the service. The railroads have made various pleas to the Interstate Commerce Commission in the past few years that they be allowed to advance rates, pointing out that they were not in position to increase their facilities by reason of insufficient remedies. They did not offer to make a bargain with the commission that if they were granted such and such rate advances they would buy so many locomotives and so many cars, and would build so much track. If they had made such an offer the commission was not authorized by existing law to bargain with them, nor was there any public sentiment that would suggest to Congress the giving of such power to the commission. It matters not whether the increase in revenue would itself have been used or would have been simply the means of improving railroad credit. The matter has usually been looked at as "the railroads borrowing money," but it is broader than that. The issue has been that of capital seeking railroad investment, whether it was in the form of money being loaned to an existing railroad or in some other form.

Railroad men are human, and they have tried to make the best of the situation in which they found themselves. The people decided that rates should be regulated and so they were regulated. The railroads let it go at that.

The people should have decided that the freight-moving facilities of the country should steadily increase year by year with the growth of the country, and should have made provision that this should occur.

The war is merely an incident. War is not the only thing that makes a people busy. We might easily have had the foundation for greater industrial activity than we have if there had been no war. The full activity would not have resulted because men would not work against such odds as they now encounter and strive to overcome because it is war, not business.

Some who comment upon the situation observe that the railroad congestion is greatest at the Atlantic seaboard, and apparently assume that this represents one of the dislocations of war because we are exporting material to our Allies and our own troops. There is much less merchant shipping than there would be at this date if there had been no war, and everyone is counting upon a very large increase in the world's merchant marine after the war, also upon a very heavy foreign commerce for the United States. That would tax the railroads much more than prosecution of the war is taxing them.

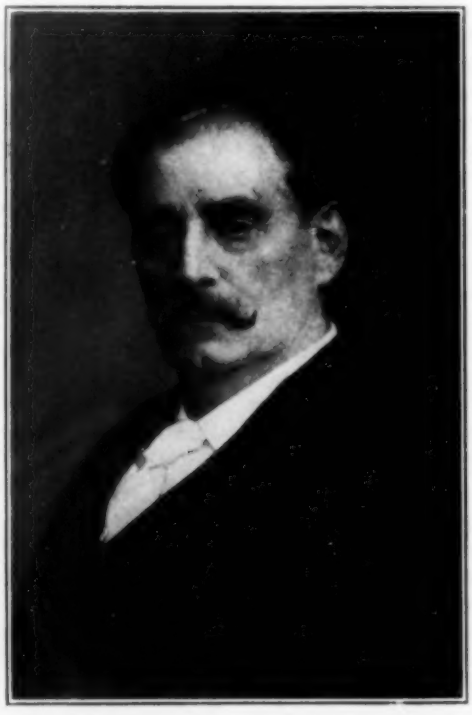
What has occurred is simply that the war has opened our eyes to the fact that the existing railroad facilities are insufficient for normal industrial activity. The country has not enough service. Limiting the wages of the servants is not sufficient. Enough servants must be provided. The Director General of Railroads recently testified before a Congressional committee that the railroads might have to be improved, under government auspices, to the extent of a billion and a half dollars being expended. In the light of such a possibility, a prospect indeed rather than a possibility, discussion of how and when the railroads shall be returned to their owners is not to the point. The country needs the traffic facilities both now and after the war. It is a detail who shall own and operate the equipment, and one that can be considered much more intelligently later than at present.

Presentation of Perkin Medal to Auguste J. Rossi

An Account of the Exercises Under Auspices of the New York Section of the Society of Chemical Industry, with Review of Mr. Rossi's Life and Work

IN accordance with an annual custom established in 1906, the New York Section of the Society of Chemical Industry made its award of the Perkin Medal at the Chemists' Club on Friday evening, January 18. The recipient was August J. Rossi, whose contributions to the metallurgy and uses of titanium have distinguished his interesting professional career since 1864.

Dr. Jerome Alexander, chairman of the section, presided. Both the dinner in the Chemists' Club dining room previous to the meeting, and the meeting itself were attended by a large and representative gathering. Rumford Hall was appropriately decorated for the occasion with American and French flags.



Auguste J. Rossi

Introductory Remarks by Dr. Jerome Alexander

Nothing could be more illustrative of the cordial solidarity that unites us to our Allies, England and France, than this evening's meeting, for here before the New York Section of a British society we are about to award the Perkin Medal to Auguste J. Rossi, a native of France.

France! How the heart of every true American, yes, of every true democrat throughout the world, leaps at the mention of that name! Fair are her fields and beautiful her cities, but France is much greater than all these—her artistic, literary, scientific and spiritual gifts to humanity and civilization have made us her debtors for all time to come, and to-day the civilized world is fighting under her slogan of "Liberty, equality, fraternity."

As a consequence of this dreadful war and under the lash of its stern necessities, we have fortunately been brought in closer relationship with our French fellow chemists. For some months past we have been planning the formation of a New York Section of the French Société de Chimie Industrielle, the sister society of the British Society of Chemical Industry, and to-night, immediately following our meeting, it will be formally organized.

We will therefore proceed with our program, and hear an account of Mr. Rossi's life and work from a gentleman well known to you all, Mr. Francis A. J. Fitz Gerald, past president of the American Electrochemical Society.

Dr. A. J. Rossi and His Work

By Francis A. J. Fitz Gerald

IT was, I think, in the year 1899 that I first made Dr. Rossi's acquaintance. There was much speculation in Niagara Falls at that time as to what he was doing. In those days there was always much gossip whenever some new work was started at Niagara Falls, for it was still in the early period of power development, before the MacFarlands and politicians got busy, and we were all watching eagerly the rapid electrochemical developments—aluminium, carborundum, caustic soda and chlorine, calcium carbide, etc. Wonderful stories would float about as to what newcomers were doing. When the Oldbury Chemical Co. started, the most astonishing stories were afloat, caused, I think, largely by the high brick wall which surrounded the factory. It was told with bated breath that this works was engaged in the manufacture of cordite by a new and secret process, and that you could not get inside the brick wall except over the body of an armed guard.

I cannot recall now what various stories were told about some remarkable work in the Porter house and the old stone barn which stood where the Acheson Graphite Company's plant now is, but these were sufficiently startling and all agreed that it was a French chemist named Rossi who was working on some new invention.

I soon made Rossi's acquaintance, for in the electrochemical work of those days there was a fine spirit of co-operation which indeed has become to a great extent permanently characteristic of Niagara Falls, and before long I got to know him very well. During visits to him I learned a great deal about his researches on the smelting of titaniferous ores, about the experiments he was then making on the manufacture and use of ferrotitanium and about many other chemical and engineering works with which he had been associated in his varied professional career. Although I may repeat some things which Dr. Rossi speaks of himself, I believe you will be interested in a brief history of his work.

In the year 1855, at the early age of 16, Rossi graduated from the University of France with the degree of

Bachelier ès Sciences et Lettres, and four years later, after he had also graduated from the École Central of Arts and Manufactures, where the studies covered mechanical, civil and metallurgical work, he came to New York. Here he soon obtained a position as assistant engineer with the Morris & Essex R. R., holding this until 1864, when the railway was taken over by the D., L. & W. After this he got a job which kept him busy for a year, making the survey of a property in Boonton, N. J., which was to be converted into a park under the direction of Mr. Calvert Vaux, the architect of Central Park, New York. Next we find him engaged in building a railway to the Boonton Iron Works, but when Fuller, Lord & Co. of that concern found out that Rossi had studied chemistry and metallurgy at the École Central they put him in charge of a laboratory at the iron works.

It was here that Rossi's attention was first called to titanium, for the ores used in the blast furnaces at the iron works were magnetites from Morris County, N. J., containing in the best samples about 1 per cent titanic oxide and in others 2.5 per cent or more. Beyond noting the existence of titanium in the ores Rossi was not particularly interested in it until he met the work of Professor Cook, the state geologist of New Jersey. This work called attention to the existence of titanium in nearly all the New Jersey ores, from fractions of 1 per cent to as high as 15 per cent titanic oxide. Professor Cook also established a relation between phosphorus and titanium in the ores, low phosphorus apparently going with high titanic oxide content. This set Rossi to work hunting up all the scanty—and, incidentally, very contradictory—literature he could find on the subject of titanium. None of this work was of any practical importance so far as the running of the Boonton Works was concerned, but several years after he had left his metallurgical work to devote his attention to tests on the pumping engines at Fall River, to calculations of the stability of the Beaver Bridge dam, to work on refrigeration and the manufacture of ice-making machinery, his researches on titanium became of value, because of a lawsuit in relation to his old firm of the Boonton Iron Works.

This lawsuit was of great importance so far as Rossi's future work was concerned, as it no doubt established his reputation as an expert in the melting of titaniferous iron ores. Thus, after Rossi had established an office in New York as a consulting engineer, and when in 1890 Mr. James McNaughton was interested in the development of the immense titaniferous ore deposits of the Adirondacks, it was to Rossi that he went for advice. Since that date Rossi has devoted most of his time to titanium.

The problem presented in this case was a study of the feasibility of smelting the titaniferous ores of the Adirondacks. Rossi, as a result of his researches years before, was well acquainted with what had been done in Europe in this field, and of special interest were the records he had of some blast furnaces near Stockton-on-Tyne, England, where ores running as high as 35 per cent titanic oxide had been smelted successfully by forming a slag that consisted of a silico-titanate of lime. This, of course, involved adding considerable quantities of lime and silica to the charge. Here lay the great objection to the Stockton-on-Tyne practice, for on account of the low iron content of the ore it was necessary to make about four tons of slag for one ton of iron.

Rossi told his client that success with the Adirondack ores could be obtained provided that the titanic oxide could be slagged off without using an enormous excess of fluxes, and that so far as the pig iron produced was concerned it would probably be of a very superior quality.

The upshot of the consultation was that Rossi went to examine the ore deposits and two small blast furnaces which had been run there by Mr. MacNaughton's grandfather from 1840 to 1858. In a curious old iron chest Rossi found the blast furnace records. Studying these and knowing the composition of the ore, the fluxes added and the amounts of these going into the charges of the old blast furnaces, Rossi found that the practice of the Stockton-on-Tyne furnaces had been anticipated. He also found that the iron produced was of such superior quality that a gold medal had been awarded it in the great London Exhibition of 1851. Moreover, certain steel made from this iron won high commendation from the navy yards of Springfield and Washington, the report stating that it compared favorably with the best Swedish steel.

Rossi then began a series of experiments on slags with the object of replacing silica with titanic oxide in the normal blast furnace slag, and following his success in this direction, built what might be described as a laboratory blast furnace in which several hundred pounds of excellent pig iron was made from the titaniferous iron ores. Next followed a small blast furnace built at the New York Car Wheel Works in Buffalo, where the Mill Pond ore, running 16 to 17 per cent iron, was successfully smelted.

In this way Rossi did the pioneer work in demonstrating the value of the great ore deposits of the Adirondacks in 1894. Twenty years later we find this work confirmed by Mr. Frank E. Bachman, general manager of the MacIntyre Iron Company, Port Henry, N. Y., in an interesting paper, "The Use of Titaniferous Ore in the Blast Furnace," presented to the American Iron and Steel Institute, October, 1914.

Turning now to ferro-titanium: Rossi was convinced from what he had observed in the work on smelting titaniferous ores that titanium had a beneficial effect on the manufacture of iron. A natural deduction from this was that an alloy of iron and titanium would be of value for the treatment of iron and steel in the process of manufacture.

This led to a series of experiments in small electric furnaces and finally to the construction of larger furnaces in Niagara Falls in 1899, where considerable quantities of ferro-titanium were manufactured, thus permitting of a great number of tests being made on a large scale in steel works and foundries.

This may be considered as closing the experimental period in the development of the manufacture and use of ferro-titanium. Rossi had now convinced himself of its value and the next problem was the education of others in its use.

I shall not go into the consideration of the commercial development of titanium, but merely discuss the principal causes of the great difficulty Rossi experienced in convincing the technical world of the value of his invention.

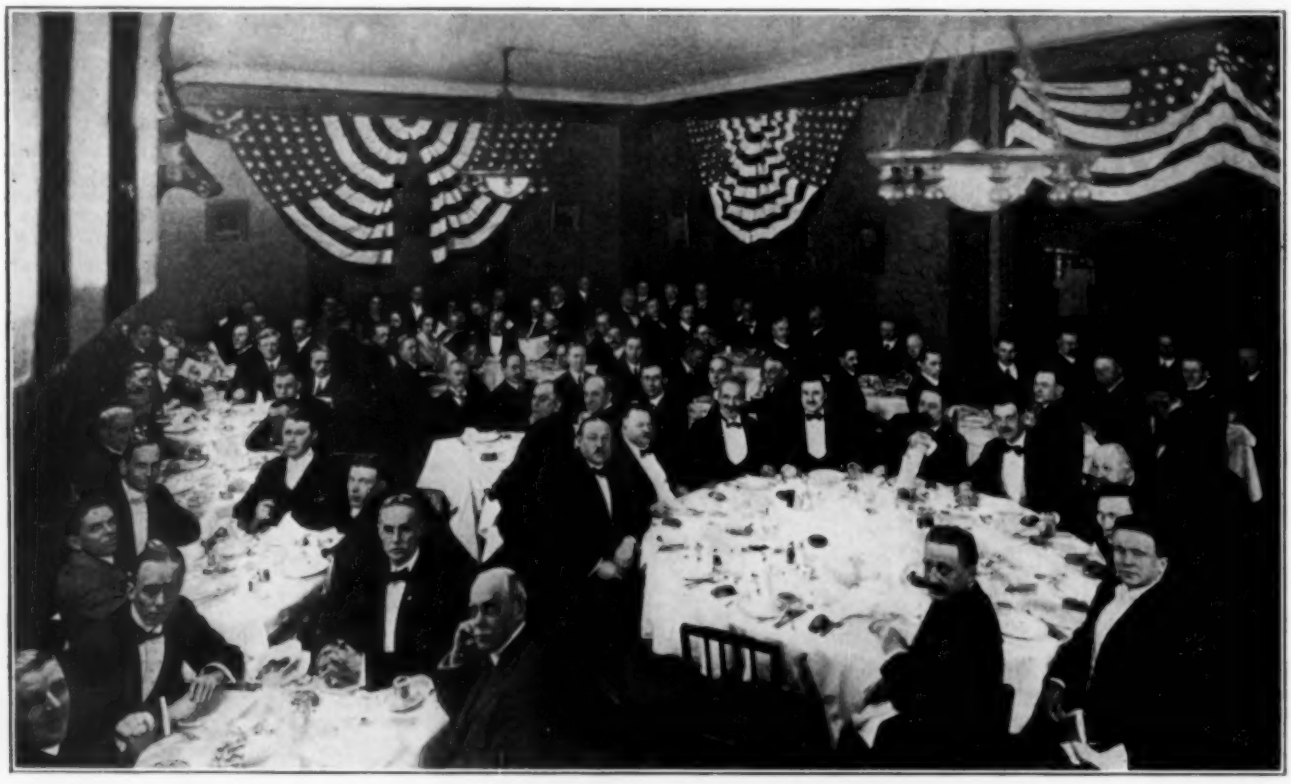
Perhaps this may be most vividly shown by means of an analogy presented by the practice of medicine.

There are a number of drugs of known value, some of them absolute specifics in the treatment of human ills, but every year we have added to our drug list a number of new medicines. Some of these are at once recognized as of real value by a few, but it often happens that their general recognition is delayed by the exaggerated enthusiasm with which they are greeted at their first appearance; moreover, it frequently happens that the injudicious use of the new drug gives it a bad name. Now, there cannot be any doubt that the very same causes which often delay true appreciation of a new medicine existed in the case of ferro-titanium. Among some there was an unwarranted enthusiasm as to the field of its usefulness and there were plenty of examples of complete failure in its application due simply to ignorance of the proper methods of using it. While, therefore, the value of ferro-titanium has always been recognized by some, there existed for a long time a prejudice against it in the minds of many, and in some quarters this exists even to-day. Thus, in spite of all Rossi showed as regards the possibilities of titanium seventeen years ago, skepticism was for long very general and is not yet completely eliminated. I hope, therefore, that you will pardon me if I call attention to a brief note I made some three years ago on certain statistics in regard to the use of titanium in rail steel, which I think very clearly disposes of the assertions made at that time that titanium has no effect on steel.

In this note are given the statistics of 155 heats, representing the production of 9,000 tons of rail steel, in some of which titanium was used while in others it was not. Where no titanium was used only 36 per cent of the steel came within the particular specification limit. Where 0.053 per cent of titanium was used, 43 per cent passed; with 0.077 per cent titanium, 84 per cent, and with 0.10 per cent titanium, 100 per cent passed.

In the earlier days of the exploitation of titanium the chief drive was made on its use in rail steel, and the data I have given show something of what can be done in that way. But of recent years much greater efforts have been expended in applying titanium to miscellaneous steels. Thus in the last ten years the ratio between titanium going into other kinds than rail steel has enormously increased, for while a decade ago the miscellaneous applications were only 12 per cent of the total they are now 96 per cent and have increased in volume about 150 times.

Thus Dr. Rossi, after more than a quarter of a century of work followed with the greatest perseverance, and undaunted by difficulties of all sorts, has not only shown what can be done with the titaniferous iron ores formerly regarded with distrust by the iron smelter, but has demonstrated that the very element supposed to make these valueless can actually be used for improving the manufacture of the metal they yield.



DINNER AT CHEMISTS' CLUB PRECEDING PRESENTATION OF PERKIN MEDAL

Address of Presentation

BY WM. H. NICHOLS†

THE world is beginning to get a gleam of what it owes to the chemist, and the chemist himself is beginning to be better understood. As a rule he works so much in the quiet of his laboratory and without the aid of that publicity which is such a prominent part in our life to-day that many of his most important discoveries are made known only to his fellow chemists, who in turn incorporate them in their own fund of knowledge and thus make use of them. Once in a while, however, something very striking comes out of a laboratory and attracts attention by its novelty or by its usefulness, or both. Under this category comes the wonderful dis-

†Past-president Society of Chemical Industry, President American Chemical Society.

covery of young Perkin, which has given the world, through those who have succeeded him, the great synthetic dye industry, the long list of synthetic remedies, and the various contributions to the "gentle art of war," which have followed Perkin's original work. What wonder, therefore, that when fifty years had elapsed, the chemists of the world should fittingly celebrate the work of the young Englishman, and what wonder that the occasion should be seized upon for the founding of a medal to be given to those who, following Perkin, should give to the world something of themselves which should forever be of great value to all mankind! Thus the Perkin Medal was founded, and thus it has annually been bestowed upon some great man who has made the world a better place to live in because he has lived in it himself.

Since the founding of the medal we have been exceedingly fortunate in having it presented annually by our own Professor Chandler, who was the first American selected to fill the great office of president of the Society of Chemical Industry. We have been in the habit of looking forward to these annual occasions, and the part which Professor Chandler would take in them, and I am sure we all greatly regret that he has not found it practicable to be with us to-night to assume this duty which we are so in the habit of associating with him. Unfortunately his health does not permit it, but let us hope that next year, and for many more to follow, he will stand in this place and perform this act in his usual graceful manner. It, therefore, falls to my lot as the next succeeding president to present the medal, and this task I undertake with great diffidence, feeling, as I do, the great disappointment which you all sustain in not hearing from the grand old man himself. It is not, however, the first time in which I have undertaken this work, as I had the honor of presenting the first Perkin Medal to Perkin himself during the jubilee celebration in New York.

It is particularly appropriate that this medal should be presented at one of the stated meetings of the New York section of that great English Society of Chemical Industry, which counted among its presidents so many great Englishmen, including Sir William himself. During the recent terrible years the members of this society have almost remade Great Britain from a chemical standpoint. Similar work of the highest grade has been accomplished by our French brethren. American chemists have taken great interest in the British society, and they are now to have an opportunity of doing similar work for the Société de Chimie Industrielle, the New York section of which is to be formed to-night. We have always had a warm place in our hearts for our French friends, and I am glad that we are going to have an opportunity of again proving this, if any proof be necessary.

You have heard from Mr. Fitz Gerald a statement of some of the work which Dr. Rossi has done, and it is not my intention to add to that list a single statement. If Mr. Fitz Gerald has omitted anything, Dr. Rossi himself will please supply as much of the deficiency as his modesty will permit.

Dr. Rossi, there have been several candidates for the honor which is to be conferred upon you to-night. The claims of each have been carefully weighed by a committee, whose only desire has been to select the candidate best qualified to receive the medal this year when everything has been considered. You have been their choice and are, after a long life full of hard work and the usual disappointments that come to every successful man, to receive the greatest reward which your fellow chemists can bestow upon you. You are joining a body of very brilliant men. You may well feel gratified that those who know best consider you worthy of the honor of that company, and in token of that selection I beg to express to you what I am sure is the thought of every man in this room, and of every other who knows your word, our hearty congratulations on a life well spent, and our cordial *bon voyage* as you turn your face to the setting sun. Coupled with this is the hope that you have before you yet many days of usefulness, and that you will be able to return our confidence with something of even greater value than what has gone before. With a heartfelt respect of the entire chemical fraternity, and a handclasp as its token, it is my privilege to present to you the Perkin Medal of 1917.

In accepting the medal Mr. Rossi expressed his heartfelt gratitude to his fellow chemists for the honor they had conferred upon him, and his appreciation of the fact that, after all, the award was not so much for personal merit as it was a recognition of those qualities of perseverance, thoroughness and devotion to science which mark all genuine research. He then gave an interesting account of his experience in the metallurgy of titanium. An excerpt of his address follows:

Development of the Metallurgy of Titanium

BY AUGUSTE J. ROSSI

MY special attention was directed to the possibilities of titaniferous iron ores in 1890 by Mr. James MacNaughton, a graduate of Yale interested in the immense Adirondack deposits as an inheritance from his grandfather, Mr. MacIntyre. These deposits were of such a magnitude that Mr. Birkinbine, then president of the American Institute of Mining Engineers, said of them at the Montreal meeting of the Institute in 1893: "Providence seems to have placed these titaniferous deposits right where they are the most inviting * * * on the headwaters of the Hudson river." I had been directed to Mr. MacNaughton by Professors Chandler and Ricketts as one who could give information on this subject, for I had had occasion previously to write a paper entitled "Titanium in the Blast Furnace" for the American Chemical Society.

Having been for some eleven years (1864-1876) technical director of the Boonton blast furnaces (Boonton Iron Works—Fuller, Lord & Co., proprietors), I knew from actual practice that the presence of titanium oxide (TiO_2) to an average of 1.5 per cent in the Morris County, New Jersey, ores, which we were smelting, and of some 2 to 2.5 per cent in our slags, had had absolutely no effect on the working of our furnaces or the behavior of our slags as to fluxidity and fusibility, so much so that I even ignored its presence and considered it as so much additional silica in the ores.

And still when the question arose of smelting these ores, alone or in mixture, one could read in the proceedings of a well-known scientific technical society "that 1 per cent of TiO_2 in a slag was enough to make it pasty to impossibility of tapping!" The advance copy of the paper (in my hands) says "that the slags had to be pulled out with tongs." How could young men new in the profession be blamed for being skeptical about the

smelting of this class of ore after such statements as I have quoted *verbatim?*

In 1876 the death of the two owners forced the closing of the Boonton Iron Works. The furnaces were blown out but not dismantled. Workmen and all had to leave and the small town was deserted for several years.

Later on in the 80's Mr. Eckert of Reading, Pa., who was making there what is called stove iron, having decided to use our puddled cinders, of which we had years of accumulation, with some of our ores containing 2 per cent TiO_2, leased the two blast furnaces which were still standing, with all the blowing apparatus and appurtenances. They made a failure of this run for technical reasons foreign to my subject and which could easily have been foreseen by one familiar with blast furnace work. However, having stopped the furnaces after a very few months' run, they tried to get out from their contract binding them to use a stipulated number of puddled cinders and ores by claiming that the presence of TiO_2 in our cinders and ores had been the cause of their failure. I was retained as an expert by the estate and had no difficulty to prove by my books of analyses and statements of founder and others that the presence of TiO_2 to the extent of their own analyses was in no way greater than the amounts which I had found during an eleven years' practice to have had absolutely no effect on the working of the same furnaces. They had to compromise and pay a heavy forfeit. I have entered into these details to render intelligible what follows.

The suit came before the Chancellor of New Jersey and I have on hand the brief submitted by the plaintiff, containing all sworn testimonies of their experts.

One of the experts, manager of one of the Durham furnaces (Cooper, Hewitt & Co.), testiled under oath that 0.75 per cent of TiO_2 in an iron ore rendered it unfit for blast-furnace purposes, as it would be only a matter of a short time before the furnace would be "clogged up" if the use of the ore were not stopped. Another(also a manager of a Durham furnace, testified under oath that not 0.75 per cent but 0.25 per cent of TiO_2 in an iron ore precluded its use in a blast furnace, it being merely a matter of a little longer time before the furnace would be clogged up. Mr. Eckert testified that "from his twenty years' practice in iron-making in blast furnaces not 0.25 per cent but *traces* (*sic*) of TiO_2 were sufficient to produce the same result as above mentioned.

Repeated Success in Smelting Titaniferous Iron Ores

This is only one of the many examples of the criticisms, prejudices and objections I met in my fight for these much abused ores. Such was the encouragement I found in the profession! Then in 1894, at the New York Car Wheel Works, Buffalo, N. Y., in a small furnace of three to four tons daily capacity, I melted, without mixture, titaniferous iron ores from the Adirondacks, containing 15 to 18 per cent TiO_2 and 55 to 56 per cent metallic iron. The slags as run from the furnace analyzed 25 to 30 per cent TiO_2, with some 15 to 18 per cent silica and lime, alumina and magnesia as bases, magnesia having been recognized by me as an essential constituent to insure the best running. These ores, being inaccessible to a railroad, had to be transported on corduroy roads to North Creek, where they could be loaded on cars. This brought their cost to $15 per ton delivered at Buffalo. This precluded the idea of making a test on a larger scale unless we could find a furnace of some ten tons capacity, which it proved impossible for us to do. Later on, within the last two years, Mr. Bachman melted similar titaniferous iron ores in one of the large blast furnaces of Weatherbee, Sherman & Co., at Porth Henry, making some 15,000 tons of a pig iron which he found of superior quality. In a very elaborate, comprehensive, scientific and technical report Mr. Bachman has given the fusibility and fluidity of the titaniferous slags run in the furnace, analyses of all materials and results of tests for strength as compared with that of the average pig irons made without titaniferous iron ores in the charges. His conclusions as a whole are a confirmation of my own as drawn from this run in Buffalo in 1894-95 in my small furnace. One of them particularly is worth mentioning, as I had come to the same conclusion in Buffalo. He says: "This run with titaniferous ores was made with an economy of fuel per ton of pig metal smelted," and yet one could read in technical publications in 1894 "that the smelting of titaniferous ores even if admissible meant such an excessive consumption of fuel per ton of iron that on this score alone they are unsuitable," leaving aside "titanium deposits in the furnace and pasty slags." This is an obvious contradiction, for if the furnace is "clogged up" by titanium which remains in the furnace, it does not go in the slag and the latter need not be pasty; or, if it goes in the slags, making them pasty, it does not remain in the furnace as titanium deposit. These titaniferous ores of the Adirondacks are magnetic, associated with ilmenite ($FeTiO_3$), an iron titanate, just as iron silicate ($FeSiO_3$) is found in certain ores (ferruginous peridotite). They are, like almost all titaniferous ores, low in phosphorus and sulphur, some as low as 0.017 per cent P and 0.02 per cent S, with 55 to 56 per cent metallic iron and 1.50 to 2 per cent SiO_2. The iron smelted from them makes an ideal open-hearth steel, and in our day open-hearth steel has superseded Bessemer steel.

Tests made by me, and in many foundries, of such pig metal added to ordinary pig iron in certain proportions has shown an increase of strength "over cast iron not treated of 29½ per cent in tests made and reported by Wm. Cramp & Co. and an increase of 4 per cent over cast iron treated with nickel."

If the results of such work as I have done, confirmed by the very recent blast-furnace runs on a large scale made by Mr. Bachman, will call the attention of metallurgists to these much abused ores, I will not have worked in vain.

Pioneer Work with Titanium as a Ferro-Alloy

But whatever value these ores may have, alone or in mixture with other ores as blast-furnace stock, their use for making alloys of iron or copper with titanium for the treatment of cast iron, steel, copper or copper alloys has opened a new and more important field of application in metallurgy.

Checked by the difficulties encountered in my efforts to secure such quantities of ore as are required for blast furnaces of our present size and capacity, I proposed to Mr. MacNaughton in 1900 to make a concentrate of titanium which, added to ordinary cast iron

or steel, would be likely to secure for the metal baths thus treated the same beneficial effect which tests had shown in pig metal smelted from these ores.

I may say here that Mr. MacNaughton was the one who supported me in these times of trial by his implicit confidence in me and the possibilities of my work.

About 1900 I started making ferro-titanium at the old Porter house in Niagara Falls by reducing titaniferous iron ores in an electric arc furnace. I used preferably those ores containing the highest percentages of TiO_2, such as ilmenite containing 40 per cent TiO_2 and 50 per cent more or less oxide of iron, or even rutile containing 93 to 95 per cent TiO_2. The furnace, being made of a masonry of graphitic material, formed the cathode and a carbon electrode, which was movable vertically by means of a mechanical device, or automatically by the current itself, formed the anode. A properly comminuted mixture of the titaniferous material and of the carbon required for reduction of both TiO_2 and oxide of iron was charged gradually into the furnace as the current was turned on. Whenever the relative proportion of TiO_2 and oxide of iron were such as to produce an alloy higher in titanium than was desired, some scrap iron was charged with the mixture to dilute the alloy, so to speak. In this manner I made alloys containing from 10 per cent to 25 per cent or more, but practice in steel and other works has shown that an alloy containing some 15 per cent of titanium was best suited for most purposes.

Whenever the presence of carbon in the ferro-carbon-titanium was considered objectionable for special applications, I reduced the titaniferous materials by my aluminium-bath process. Instead of using a mixture of finely powdered aluminium and titaniferous material, as in Goldschmidt's thermit process, the aluminium I used for the reduction of the oxides was melted in the electric furnace and the titaniferous materials charged directly into the bath. In such cases I used preferably TiO_2 as rutile in order to avoid using the aluminium which would have been required for the reduction of the oxide of iron of the ore, charging scrap iron with the rutile to dilute the alloy to the desired content of titanium. In this manner I made ferro-titanium practically free from carbon, containing only from 0.18 to 0.50 carbon, and by reducing the amount of scrap iron added I was able to make ferro-titanium as high as 80 to 85 per cent titanium.

Titanium as a metal is as white and as shining as silver, but very hard and brittle, so that it has no particular use as such. Alloys high in titanium, such as 75 to 85 per cent, and even those with less tenure in titanium, are also white like silver and scratch glass and even quartz deeply.

This aluminium bath process is of more general application. Thus if a tungstic ore containing oxide of iron is charged, a ferro-tungsten is obtained free from carbon. I have made thus 85 per cent tungsten alloy. By using manganiferous ores I was able to make in the electric furnace 85 to 88 per cent ferro-manganese free from carbon, and by using chromic iron, a ferro-chrome of about 80 per cent chromium free from carbon.

Effect of Titanium in Steel

By adding to a bath of steel or to cast iron a ferro-carbon-titanium containing some 15 per cent of titanium, the bath of metal was cleansed from dissolved or occluded gases, such as oxygen and nitrogen, and from oxides of iron generally present in steel, specially in Bessemer steel. When air is blown through the molten pig iron the titanium of the alloy combines with oxygen as TiO_2; with nitrogen as titanium nitride. The oxide of iron is reduced to iron by the titanium and the carbon of the alloy, the titanium combining with its oxygen to form TiO_2. The slag, always present in metallic bath, rises and carries with it the titanic dioxide and the titanium nitride to the top of the ingot or ladle. The TiO_2 entering the slag renders it more fluid and fusible, as proved by experiments I have carried on for Dr. P. H. Dudley, the expert of the N. Y. C. R. R. A slag collected by him at the top of an ingot and containing 6½ per cent of TiO_2 had a melting point of 1290 deg. C., lower than or about the same as that of an ordinary blast-furnace slag. By adding enough TiO_2 to such a slag to have in it some 13 per cent TiO_2, its melting point was lowered to 1190 deg. C., as determined by Mr. Fitz Gerald.

The presence of titanium in steel to the extent of 1 per cent or more imparts to the steel certain very special properties to which, later on, I may have occasion to direct your attention. The head of a crucible-steel ingot treated with titanium cast in 1900 at Atha & Illingworth, East Newark, had five holes drilled in it to obtain specimens for analysis. These holes are as bright now as they were when first drilled, though exposed to the air in my office. This ingot contains 1.10 to 1 per cent titanium, and the steel was so hard that it was drilled with difficulty.

Copper, as is well known, absorbs when melted, a large amount of gases, and the bath contains oxide of copper. For the treatment of copper and its alloys, such as bronze, brass, manganese or aluminium bronze, I have made a copper-titanium containing any amount of titanium, though 10 to 15 per cent appears better adapted as a scavenger of the copper bath. I have also made aluminium-titanium containing 45 per cent titanium for seasoning aluminium bronzes. They are made in the same manner as ferro-carbon-titanium or ferro-titanium in the electric furnace. For copper-titanium, TiO_2 and aluminium are charged in the furnace in a bath of copper. For aluminium titanium, the TiO_2 is charged directly in the bath of aluminium. The reaction of aluminium on oxides being exothermic, much less current is required for the reduction proper.

As is well known, the affinity of titanium for O and N is such that the metal burns at 800 deg. C. or thereabout in an atmosphere of these gases. (Wöhler and St. Claire Deville). It is so strong that when large cakes of alloy free from carbon are broken while hot the section exposed to the air colors itself with fine iridescence, presenting all the colors of the rainbow: blue (probable TiO), gold (probably nitride), copper (probably cyanonitride formed by the small amount of carbon still present), and combinations of these.

I have experimented with ores containing 1.50 to 2 per cent of phosphorus, adding even apatite (lime phosphate) to the mixture, so as to obtain a pig iron as high in phosphorus as I could. Contrary to what might have been expected, the pig metal containing 0.40 titanium and from 2.50 to 3.50 per cent phosphorus had the strength of fair No. 1 or No. 2 pig iron. This suggested treating phosphoric pig metal, generally weak and close grained, with ferro-titanium, so as to incor-

porate a divided amount of titanium in it. The results were very encouraging and were presented by me at the Pittsburgh meeting of the A. I. M. E. in 1896.

I have also experimented with the smelting of titaniferous ores in mixture with manganiferous ores, even in a coke furnace. I was able to introduce some 3 per cent to 3.50 per cent of titanium in cast iron, and by addition of MnO_2 the pig iron contained 2 to 3 per cent Mn. Manganese appears to cause the titanium to pass into the cast iron, as it alloys readily with titanium.

Other Titanium Compounds

If a ferro-titanium practically free from carbon, made by my aluminium bath method, preferably as high in titanium and low in iron as possible, is dissolved in hydrochloric acid, a fine violet solution is obtained—a ferrous titanium chloride. With this violet solution I have been able to bleach cotton, silk and wool. As is well known, silk and wool cannot be bleached in agents capable of generating free chlorine, which injures and attacks these fabrics. Still I was able to bleach completely some 2000 yards of such fabrics by digesting them in this diluted violet solution, boiling for a shorter or longer time, according to the intensity of the dye to be bleached or the yellowish tint of the white fabrics. Silk and wool, colored or yellowish, were thus bleached without injury to the fabrics. The double chloride contained about 40 to 50 per cent $TiCl_2$, titanous chloride, the balance ferrous chloride. During the operation, especially as the temperature reached near the boiling point, TiO_2 precipitated, thus showing clearly that the chlorine must have been set free and must have combined with the ferrous chloride to form ferric chloride, the chlorine generated acting in the nascent state without even coming as free chlorine in solution.

The fact that TiO_2 was precipitated from one of its compounds by organic matter suggested to me the possibilities of precipitating TiO_2 from others of its compounds by vegetal or animal organic matter. The results were very remarkable. If to a solution of titanic sulphate $Ti(SO_4)_2$ is added a water extract of organic vegetal or animal substance, and the liquid gently digested to boiling and boiled for a short time, TiO_2 is precipitated and, when calcined, is obtained as a soft, smooth, flourlike, pure white powder, requiring no mechanical pulverization. This is such a characteristic of the action of these organic substances that a number of them, such as water extracts obtained from dry leaves, green leaves, sawdust, tannin, wood pulp, wood-pulp liquor, horse chestnuts, beans, docks, cranberries, radishes, etc., and urea itself, have given the same results. One of the interesting features of this process of obtaining TiO_2 pure white and smooth in impalpable powder is that if this same titanic sulphate solution be precipitated by NH_3 or Na_2O, and boiled, the TiO_2 calcined is granular.

This method finds a direct application in the production of a white titanic pigment, a product which our company is to manufacture on a large scale. Calcined TiO_2 possesses a remarkable property of covering when used as paint material, alone or in mixture with such other pigments as are used in the trade for paints. Its superiority on this score, when prepared with proper oils, over white lead or white zinc is remarkable, and, besides, TiO_2 pigment is not attacked by gases.

Chemical Alliance to Meet

THE first annual meeting of the Chemical Alliance, Inc., will be held at the Hotel Biltmore, New York, on Wednesday, Feb. 6, at 9 a. m. As previously stated in our columns, the Chemical Alliance, Inc., has taken over the work of the Committee on Chemicals of the Council of National Defense, and has a permanent office at 540 Woodward Building, Washington, D. C. Membership in the alliance is open to all individuals, firms or corporations in the United States engaged in the chemical or allied industries. The annual dues are $25 with no entrance fee charged. Sections already organized include Acids; Coal Tar By-Products; Electrochemical; Fertilizers; Alkali, and others. The meeting on Feb. 6 will be open to qualified manufacturers whether or not they are yet members. A large attendance is anticipated.

American Dyestuff Industry Organizes

ALMOST important forward step was taken by American dyestuff manufacturers and allied interests when they formed a permanent organization at the Chemists' Club in New York on Jan. 22 and 23. Practically all of the important manufacturers and dealers were present and the interest shown and results accomplished speak well for the future of the industry in this country.

The meeting was called to order at 10.30 a. m. on Jan. 22 by H. Gardner McKerrow, the father of the movement to form a permanent organization. Frank Hemingway was chosen temporary chairman and made a short speech outlining his idea of what the aims of the organization should be. He laid especial emphasis on the value of meeting together socially and discussing each other's problems. He urged a quality membership and the formation of a committee of organization. C. D. Jenkinson of the National City Bank was chosen temporary treasurer and C. C. Bennett of the Color Trade Journal, temporary secretary.

The chairman then called on Mr. McKerrow to outline the objects of the convention. Mr. McKerrow mentioned some of the pressing problems confronting the dye industry, such as standardization, tariff, patent laws, arbitration of disputes, prevention of inferior exports, protection of contracts, etc. Others who spoke during the two days were Dr. J. Merritt Matthews, Dr. Wallace Pierce of the United States Conditioning and Testing Laboratories, who spoke on "Standardization," Mr. Bradford Webster, who spoke on "Arbitration," Mr. A. E. Parker, who spoke on "Patent Law," and Dr. Grinnell Jones, who told of the work the Tariff Commission is doing in regard to the dyestuffs tariff. Dr. Jones has been asked to make recommendations to the commission in about four weeks. A committee was appointed to confer with Dr. Jones.

On the first day of the meeting an organization committee was formed consisting of Messrs. L. A. Ault, J. Merritt Matthews, Mr. David, H. G. McKerrow, August Merz, Mr. Woodward and Mr. Hyndman. This committee will formulate recommendations for a name for the organization, by-laws, classes of membership, etc., and report at the Annual meeting to be held March 6 at the Chemists' Club.

The Physical Properties of Copper and the Factors by Which They Are Affected—I*

BY PAUL D. MERICA
Division of Metallurgy, U. S. Bureau of Standards

At no time in the history of the technology of metals, their production and manufacture, has the necessity for accurate information concerning their general physical properties been more keenly recognized in the industries than to-day. The day is not far past when the scientist, either chemist or physicist, in the manufacturing plant was considered a luxury, and qualitative or even comparative knowledge of the characteristics of materials was considered quite sufficient for every-day plant operation. With industry's tremendous growth and ramification, however, has come increased demands for performance upon the materials at its disposal, which has been possible of fulfillment only through more detailed and accurate study of the characteristics of these materials than was considered necessary before. Not only has it become necessary to study more thoroughly and quantitatively than before characteristics which already were utilized, but it has become necessary to pay attention to characteristics of materials which formerly were hardly considered of more than merely scientific interest. Thus have the thermo-electric properties of metals been of late the subject of quite intensive investigation.

This growing realization of the manufacturing industries, that increasingly they require accurate physical data on metals and alloys, has been borne in upon the writer by the numerous requests for such information which come to the Bureau of Standards, and so frequently has he had occasion to search the literature for accurate and dependable data concerning this or that characteristic of a metal or alloy in answer to their requests and for his own purposes, that he has often wished that such might have been grouped in one place, that it might be more generally and readily accessible to those for whom it is of interest.

In view of these demands therefore it seemed of sufficient importance that an attempt has been made, as a beginning, to assemble for the metal copper all of the most reputable physical data in the form of a sort of handbook of information, as well as to give the complete bibliography of the data for those who might wish to examine them critically. In this compilation the data and information have been put in the form of tables and curves, the latter being reproduced in such dimensions that accurate interpolation of values on them is possible by the use of a rule graduated in decimal parts of an inch. The probable degree of accuracy of data is indicated by the number of significant figures in the values given. The bibliography is given at the end and contains the sources to which the numbers refer.

The actual labor of assembling these data has been most amply repaid, the author feels, by the instructive facts which have thereby been brought to his attention.

In the first place it is most interesting to note the characteristics which have received the most attention and which have been quantitatively most accurately studied—characteristics, almost always, of technical and industrial significance, as for example, electrical conductivity, in the case of copper. Industry has been served by science as never before.

Another interesting fact is apparent in the study of such data, namely, the lack of recognition on the part of the scientist who has measured physical properties of the magnitude of the effect of the physical state and the chemical purity or composition upon these properties. The author has seen instances in which a property has been measured most carefully and by most elaborate apparatus, using a sample of material not physically or chemically sufficiently defined that an error of ten times the experimental error would have been of significance. It has remained for the experience of the manufacturer and producer of metals to guide the physicist in his physical studies of such material.

This article therefore attempts to consider the physical data of copper in relation to the chemical purity of the copper and to its physical state, by which these properties are often most markedly affected. There are several chapters which could be most satisfactorily elaborated if the experience of several manufacturers in copper were available, such as that for example on the defects or "disease" of copper, and that upon the effect of impurities on the properties of copper. It is to be regretted that information of this sort which is based upon day-by-day close observation of this metal and which is of such great technical significance should not be at least in large part the property of the technical world; if this article by its very incompleteness in those chapters induces a change in the attitude of those having such private store of information, it will have most amply served its purpose.

METALLOGRAPHY OF COPPER

The purest copper produced commercially, that which has been electro-deposited and not remelted, or has been remelted *in vacuo*, consists structurally of an aggregate of copper grains or crystals, the latter belonging to the regular or cubic system. Photomicrographs, Figs. 1 and 2, show pure electrolytic copper as deposited in the form of cathode strip, not remelted. Figs. 3 and 4 show copper as deposited in the form of electrotypes (38), and show the twinning in the columnar crystals and the etching pits inside of the grains.

When copper is remelted, it takes up oxygen, only part of which is removed by poling, such that about 0.05 per cent remains in the ingots cast from the fur-

*Extract from forthcoming Bureau of Standards' circular on copper.

FIG. 1. CATHODE COPPER. × 100

FIG. 2. CATHODE COPPER. × 100

FIG. 3. ELECTROTYPE COPPER. × 300

FIG. 4. ELECTROTYPE COPPER. × 500

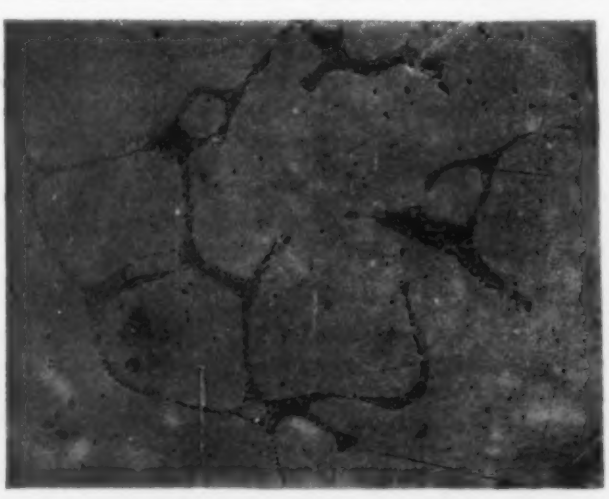


FIG. 5. CAST COPPER CONTAINING ABOUT 0.05 PER CENT OXYGEN. ×100

FIG. 6. HARD-DRAWN TROLLEY WIRE, 23/64 IN. × 250

nace. The appearance of such cast copper is shown in Fig. 5. The oyxgen is present as Cu_2O, which forms a eutectic with copper of the composition 3.45 per cent Cu_2O, melting at 1063 deg. C.; it is not appreciably soluble in solid copper. It presents under the microscope a bluish-gray appearance with a characteristic

FIG. 7. MEDIUM-DRAWN WIRE, 7/64 IN. × 250

FIG. 8. SOFT WIRE, ¼ IN. × 250

red "glow" at the center of each particle, and cannot be confused with other inclusions in copper. The Cu_2O content of cast copper may be readily determined planimetrically from photomicrographs or on microscope ground glass (33).

The structure of such cast copper is broken up by the mechanical and heat treatment it receives in the mill, and it recrystallizes, appearing as shown in Figs. 6, 7, 8 and 9, illustrating different forms of commercial copper. The oxide is present in rows of fine globules, parallel to the axis of forging or working.

In the hard-drawn copper (Fig. 6) the grains are crossed by numerous etch-bands, perpendicular to the direction of drawing, and characteristic of hard copper; the grains are also elongated in the same direction. This is true also, but in less degree, of the medium-drawn wire, Fig. 7. When hard-drawn copper is annealed it recrystallizes; fine grains make their appearance within the larger original strained grains and generally at the border of the grains or along twinning planes and grow. The recrystallization takes place simultaneously with the softening of the metal; the temperature ranges of recrystallization coincide with those of the annealing softening (see Fig. 19), *i. e.*, from 250 deg. to 400 deg. C. After a full anneal the metal assumes the structural appearance shown in Fig. 8.

Figs. 9 and 10 show the appearance of hot-rolled copper plate or sheet, ¼ in. thick.

The grain size of copper may vary within wide limits. When just recrystallized, after cold-drawing or rolling, the grains will have diameters of from 0.0005 to 0.003 in. approximately, whereas after annealing at higher temperatures the diameters may go up to from .005 to .015 in. The grain size depends upon the extent of the reduction and of the annealing; this in commercial practice depends on the size of specimen, so that one may find in hard-drawn heavy sections a grain size larger than in soft smaller sections. The presence of oxide particles has been shown to hinder grain growth, in preventing coalescence of the adjoining grains.

Besides Cu_2O, bismuth and lead, when present in copper, are present at least except in quite small amounts (see below) as discreet particles, visible under the microscope. Other impurities, silver, gold, nickel, manganese, arsenic, antimony, zinc, phosphorus, etc., dissolve to a greater or less extent in the solid copper and leave no microscopic trace of their presence, except pos-

FIG. 9. HOT-ROLLED ¼-IN. SHEET. × 100

FIG. 10. GASSED COPPER—CRACKS. × 100

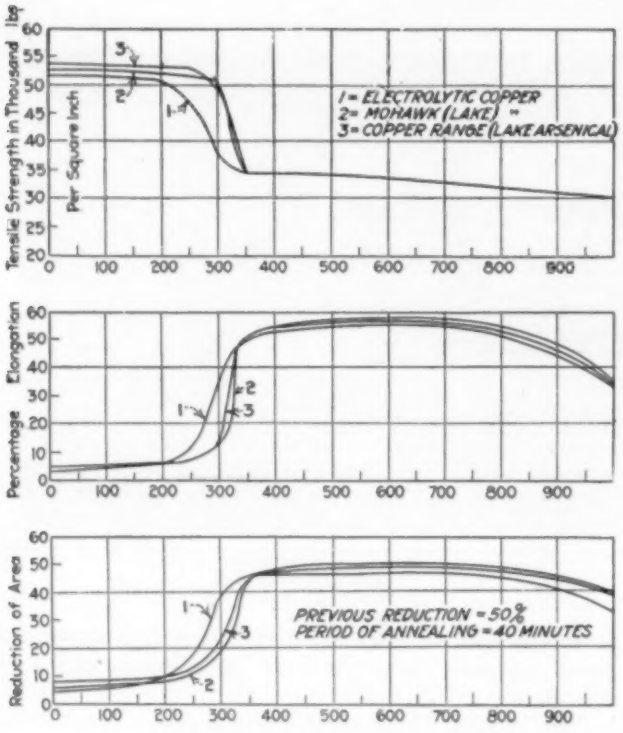

Tensile Strength in Thousand lbs Per Square Inch
1 = ELECTROLYTIC COPPER
2 = MOHAWK (LAKE) "
3 = COPPER RANGE (LAKE ARSENICAL)
Percentage Elongation
Reduction of Area
PREVIOUS REDUCTION = 50%
PERIOD OF ANNEALING = 40 MINUTES

FIG. 19. EFFECT OF ANNEALING ON MECHANICAL PROPERTIES (TENSILE TEST) OF COMMERCIAL VARIETIES OF COPPER (191)

	% Oxygen	% Arsenic + Antimony	% Silver
Curve 1. Electrolytic copper	.071	.000	.0005
Curve 2. Mohawk copper (Lake)..	.052	.096	.069
Curve 3. Copper Range copper (Lake arsenical)	.055	.296	.052

Previous reduction 50%.

sibly in the cast state, when their presence gives a cored or dendritic structure to the metal.

Copper is best etched for microscopic examination with ammonium hydroxide, with ammonium persulphate solution or with a combination of the two; hydrogen peroxide may be used with ammonium hydroxide in place of ammonium persulphate.

Bragg (35) has shown by his method of X-ray examination that the copper atoms in crystalline copper are arranged in a face-centered cubic lattice; there is therefore apparently no copper molecule in solid copper smaller in size than the grain itself.

1. Possible Allotropy; Transformation

It is generally assumed that copper does not exist in any allotropic forms, but that the form which is stable at ordinary temperature persists also at lower and higher temperatures. Thermal analysis and microscopic examination disclose no evidence of any chemical transformation of any sort.

Cohen and his co-workers (42, 43) from measurements and consideration of the thermal expansion and electrical resistance, believed that they had discovered in electrolytic copper a transformation point at about 70 deg. C. The very careful electrical resistivity measurements of Burgess and Kellberg (41) do not however indicate any such point; the electrical resistivity varies almost linearly in a smooth curve between 61 deg. and 74 deg. C. The results of Cohen are possibly to be attributed to the presence of Cu_2O in the copper tested or to the fact that the chips or wire used were in a state of initial stress or of unstable (fine) crystal structure.

Schützenberger's (45) allotropic copper has been shown by Benedicks to owe its properties to inclusions of Cu_2O and acetate of copper. It is harder and more brittle than copper and is made by the electrolysis of slightly alkaline solutions of copper acetate.

CHEMICAL PROPERTIES

Copper is not oxidized in dry air at ordinary temperature nor in moist air in the absence of CO_2. In dry air the oxidation at temperatures under 180 deg. C. is insignificant; above that temperature are formed CuO and Cu_2O. It is not readily attacked at temperatures below the melting point by H_2, N_2, CO, CO_2, or H_2O. Elliott claims that superheated steam makes copper brittle. In the presence of NH_4OH copper is readily oxidized in air; this reaction is utilized as a method of ozone O_3 absorption.

Copper does not dissolve in the absence of air in dilute HCl or dilute H_2SO_4, but readily in HNO_3, and also in KCN. In the presence of air, dilute acids, including certain organic acids, attack it slowly; at higher temperatures concentrated H_2SO_4 attacks it, forming SO_2, $CuSO_4$, etc. It is also corroded slowly by saline solutions and sea water.

Foerster (3) discusses the anodic and cathodic electrochemical behavior of copper, characteristics of great importance to the electrolytic refining industry.

Heath (8) describes the methods in use for the analysis of copper and its alloys.

PHYSICAL PROPERTIES

1. Electrical, Magnetic

(*a*) *Electrical Conductivity.* — The International Electrotechnical Commission in 1913 adopted the present international standard value for the electrical resistivity of annealed copper; this is

0.15328 ohm (meter, gram) at 20 deg. C.
0.017241 ohm (meter, mm^2) at 20 deg. C.
0.67879 microhm (cu. in.) at 20 deg. C.

This value is based upon the values obtained by the various national physical laboratories (49, 60) for ordinary high-grade commercial refined copper in the annealed state; it represents an average value for such materials. The standard density is 8.89 grams per cubic centimeter.

Investigation made at this bureau showed that for 89 annealed samples of the purest commercial copper from fourteen refiners the mean value of the resistivity was 0.15292 ohms (meter, gram), the average deviation from this value being 0.26 per cent, the maximum, 1.7 per cent. It is thus seen that even in the purest grades of copper the variation in purity and physical state are sufficient to cause variations in resistivity of annealed samples of about ± 1.5 per cent. Some of the highest values found for the per cent conductivity of copper are the following:

Resistivity = 0.15045 ohms (meter, gram) at 20 deg. C. (annealed wire).
Per cent conductivity = 101.88 per cent.
Resistivity = 0.15386 ohms (meter, gram) at 20 deg. C. (hard-drawn wire).
Per cent conductivity = 99.62 per cent.

The first value (60) is for an annealed wire drawn

directly from a mass of native lake copper which had never been melted. The second value is for a hard-drawn sample drawn directly from a cathode plate without remelting. The average difference between the conductivity of hard-drawn and of annealed copper is 2.7 per cent.

It may be noted that in the investigation by this bureau of about ninety samples of commercial pure copper, the electrolytic samples, annealed, gave a mean value of 100.3 per cent, the lake samples, one of 100.02 per cent conductivity. The electrolytic samples also averaged about 0.40 per cent higher than the lake samples in the hard-drawn condition. According to Mr. Bassett, Technical Superintendent and Metallurgist, American Brass Co., "it is not uncommon to find a conductivity in commercial wire bars of 101.3 per cent to 101.6 per cent when soft-annealed."

It may be noted that the electrical conductivity, as also its temperature coefficient, afford very sensitive criteria of the purity of copper, and are most convenient

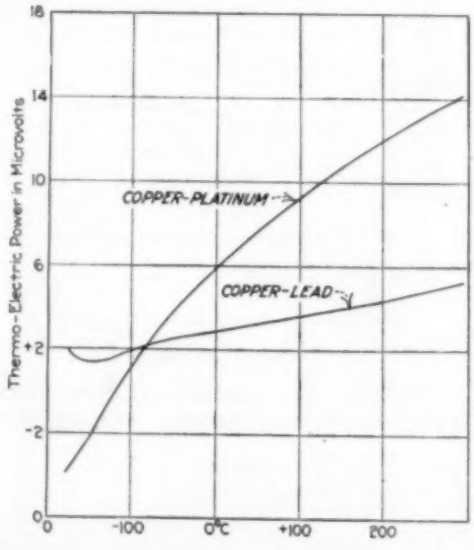


FIG. 11. THERMO-ELECTRIC POWER OF COPPER TO PLATINUM AND TO LEAD. (ADAMS)

when the metal is to be tested in the form of wire or rod.

Within the temperature limits 10 deg. to 100 deg. C. the conductivity of copper is a linear function of the temperature (within 0.2 per cent) (50), and the temperature coefficient of resistance is proportional to the conductivity; e. g.

$$\alpha\ 20° = 0.0000393 \times \text{per cent conductivity.}$$

Thus as a consequence of this relation the change in resistivity per degree centigrade is a constant for copper, independent of the temperature (10 deg.-100 deg. C.) and of the purity, and is equal to 0.000597 ohm (meter, gram, deg. C.).

(*b*) ***Thermo-Electromotive Force, Peltier Effect, Thomson Effect.***—In. Fig. 11 are given the curves of the thermo-electric power (dE/dt) of commercially pure copper to pure lead and platinum as determined by Dr. Adams (61), of the Geophysical Laboratory of the Carnegie Institution. According to him the thermal emf. of different samples of commercial copper wire to lead or platinum does not vary by more than 5 microvolts at 200 deg. C., showing a remarkable homogeneity of this metal in its commercial form. From these curves cubic equations have been derived as follows:

$$\text{(Cu-Pt)}\ \frac{\delta E}{\delta t} = 5.85 + 0.0406t - 7.46 \times 10^{-5}t^2 + 1.096 \times 10^{-7}t^3$$

$$\text{(Cu-Pb)}\ \frac{\delta E}{\delta t} = 2.84 + 0.0082 - 0.84 \times 10^{-5}t^2 + 0.226 \times 10^{-7}t^3$$

The thermal emf.'s are obtained by integration as follows:

$$E^t{}_o = \int_o^t \frac{\delta E}{\delta t}\ dt$$

$$\text{(Cu-Pt)}\ E^t{}_o = 5.85 + 0.0203t^2 - 2.48 \times 10^{-5}t^3 + 0.274 \times 10^{-7}t^4$$

$$\text{(Cu-Pb)}\ E^t{}_o = 2.84 + 0.0041t^2 - 0.28 \times 10^{-5}t^3 + 0.0565 \times 10^{-7}t^4$$

The emf. of copper to lead was calculated from the direct data of Adams on the emf. of copper-lead and of lead-platinum.

Adams and Johnston (62) give a general equation for the copper constantan couple, to be used in connection with deviation curves given by Sosman (66). The equation is:

$$E = 38.105t + 0.04442t^2 - 0.00002856t^3$$

The Peltier and Thomson effects may be calculated from the above equations.

(*c*) *Electrolytic Solution Potential.*—The electrolytic solution potential of copper to a solution containing its (bivalent) ions is given by Neuman (74), who found for

Cu/*N*CuSo$_4$(18 deg. C.)/normal hydrogen electrode: $E_h =$

-0.308 (Cu ion concentration $= 0.11\ N$)

E_h calculated $=$

-0.329 (Cu ions in $CuSO_4$ solution of $/N$ concentration)

Labendzinski (73) has determined with care the emf. of copper to its cupric salts. His results are as follows:

	Normality	E_h
$Cu/CuSO_4$	1.0	+ 0.304
	0.1	.284
	0.01	.262
$Cu/Cu(NO_3)_2$	1.0	.331
	0.1	.294
	0.01	.266
Cu/Cu (acetate)	Saturated	.278
	0.1	.264
	0.01	.242

Cohen (69) has shown that the emf. of copper amalgams of mercury content of from 1 to 16 per cent to a saturated solution of $CuSO_4$ at 25 deg. C. to Hg_2SO_4/Hg is 0.3471 volts.

The emf. of copper to solutions containing cuprous ions has been studied by Bodländer-Storbeck (71). They find that for Cu/0.05 *N*KCl + saturated CuCl:

$$E_h = -0.194 \text{ volts}$$

The emf. of copper to solutions of its salts (cupric) become less negative with increase of temperature (72). The temperature coefficient of emf. between 0 deg.-50 deg. C. is

$$\alpha = 0.00066 \text{ volts per degree C.}$$

(*d*) ***Magnetic Properties.***—Pure copper is diamagnetic. Its magnetic behavior is very profoundly altered by slight traces of iron present as an impurity. Thus as little at 0.04 per cent of iron makes copper paramagnetic (75, 77). Values given for K, the susceptibility, are

$K_l = -0.66 \times 10^{-6}$ (79)

$= -0.82 \times 10^{-6}$ (electrolytic copper) (78)

$K_m = -1.22 \times 10^{-6}$ (native copper) (76)

$= -0.086 \times 10^{-4}$ (electrolytic copper; Fe = 0.008 per cent) (80)

$= -0.085 \times 10^{-4}$ (electrolytic copper; Fe = 0.0004 per cent) (81)

The value of K may thus be taken as -0.085×10^{-4} for pure copper. The temperature coefficient of K is given by the equation (78).

$$\alpha_0 = -0.0015$$

that is, the value of K decreases with increase of temperature.

Cu_2O and CuO have been found to be paramagnetic. (75)

$$K_{(CuO)} = \text{about} + 20.0 \times 10^{-6}$$
$$K_{(Cu_2O)} = +0.62 \times 10^{-6}$$

2. Thermal and Optical

(*a*) *Melting Point, Heat of Fusion, Boiling Point, Vapor Pressure.*—The *melting point* of copper is taken as 1083.0 deg. C., the value adopted by the Bureau (87) in standardization of pyrometers, etc. Small amounts of oxygen lower the melting point markedly; the melting point of the eutectic Cu-Cu_2O (3.45 per cent Cu_2O = 0.395 per cent oxygen) being about 1063 deg. C.

Richards-Frazier (105) give 43.3 calories as the *heat of fusion* of copper.

It has not been possible to determine the *boiling point* of copper accurately; this has been due largely to the experimental difficulties. Greenwood (83, 84) states that there is an interval of about 100 deg. C. between the temperature at which copper first begins to form bubbles and that temperature at which ebullition is vigorous. This latter temperature he gives as 2310 deg. C. at 760-mm. pressure, as measured with a Wanner optical pyrometer on electrolytic copper in an atmosphere of hydrogen, and states that it can readily be duplicated.

V. Wartenberg (87) states that the boiling point of copper lies above 2200 deg. C., and Féry (82) places it at 2100 deg. C.

Greenwood (84) also made three determinations of the vapor pressure of copper, his values being:

at 2310 deg. C., 1.0 atmosphere
2180 deg. C., 0.34 atmosphere
1980 deg. C., 0.13 atmosphere

From these data Johnson (85) has given the formula

$$\log p = 9.14 - \frac{16{,}400}{T}$$

p = vapor pressure in mm. of mercury.
T = absolute temperature.

This gives a pressure of 0.001 mm. at 1080 deg. C. From this formula it follows (Johnson, *loc. cit.*) that the heat of vaporization of copper is about 75,000 calories.

(*b*) *Thermal Conductivity.*—An empirical law, approximate only, of Wiedemann-Franz-Lorenz connects the thermal conductivity of pure metals with the electrical conductivity by the following relation:

$$\frac{\text{Thermal conductivity}}{\text{electrical conductivity}} = K \times (\text{absolute temperature})$$

Determination of both conductivities was made in 1900 at the Physikalish-Technische Reichsanstalt (90) on a "pure copper" (traces of iron and zinc, together less than 0.05 per cent). The results were as follows:

Electrical resistivity (18 deg. C.) = 0.01782 ohms (meter, mm.²), conductivity of 96.8 per cent (international standard)

Temperature coefficient of electrical resistivity at 18 deg. C. = 0.00393

Thermal conductivity (18 deg. C.) = 3.73

$$\frac{\text{watt seconds}}{\text{cm. second. degree}}$$

Temperature coefficient of thermal conductivity = 1.96×10^{-4}

$$\text{Ratio}\left(\frac{\text{thermal conductivity}}{\text{electrical conductivity}}\right) = 665 \times 10^{-6} \text{ (18 deg. C.)}$$

Temperature coefficient of this ratio = 3.67×10^{-3}

Schaufelberger (92) obtained in 1902 a value of 0.9382

$$\frac{\text{Calorie}}{\text{second. gram. degree. centigrade}}$$

for "pure copper." The electrical conductivity of this material is however only 92.8 per cent, showing the material to be inferior in purity to that used by Jaeger and Dieselhorst.

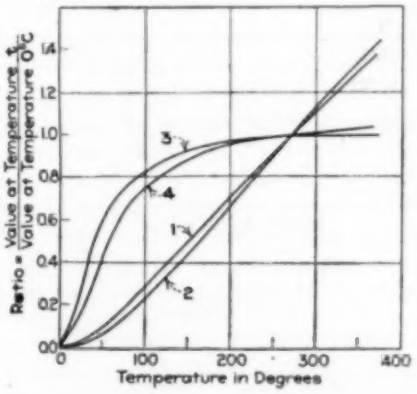


FIG. 12. THERMAL AND ELECTRICAL CONDUCTIVITY AT LOW AND HIGHER TEMPERATURE. (MEISSNER, 91)

Curve 1. $\lambda/\chi = \frac{\text{thermal}}{\text{electrical}}$ conductivity.
Curve 2. $1/\chi$ = electrical resistivity.
Curve 3. $1/\lambda$ = thermal resistivity.
Curve 4. $\lambda/\chi T = \frac{\text{thermal conductivity}}{\text{electrical conductivity} \times \text{abs. temperature}}$.
All quantities expressed as fraction of respective values at deg. C. The portion of curve between 0 deg. and 20 deg. abs. is extrapolated.

At lower temperatures, divergence from the Wiedemann-Franz-Lorenz law is still greater. The variation of the two conductivities and their ratio between 20 deg. and 400 deg. absolute is given by Meissner (91) in Fig. 12.

(*c*) *Thermal expansion.*—The linear thermal expansion of copper is not a linear function of the temperature but is well expressed (at least from −40 to +300 deg. C.) by a quadratic equation.

The thermal expansion of two samples of electrolytic copper furnished by the American Brass Co. has been determined at this bureau.

One sample was in the form of hot-rolled and cold drawn trolley wire of N.E.C. copper wire-bar, of the following analysis:

	Per Cent		Per Cent
Copper	99.956	Nickel	.001
Silver	.0005	Selenium	.0000
Iron	.0006	Tellurium	
Lead	.0007	Sulphur	.001
Arsenic	.0025	Zinc	.000
Antimony	.0011	Oxygen (diff.)	.03

This sample showed between —24 deg. C. and +64 deg. C. a unit linear expansion, expressed (within 0.000003) by the following equation:

$$\frac{\Delta l}{l_o} = (16.48t + 0.00382t^2)10^{-6}$$

Another sample of electrolytic copper, battery assay 99.968 per cent Cu, hot-rolled, drawn and annealed, showed between — 49 deg. and + 305 deg. C. an expansion, expressed (within 0.000009) by the equation:

$$\frac{\Delta l}{l_o} = (16.34t + 0.00413t^2)10^{-6}$$

Dittenberger (95) gives the following equation for results determined between 0 deg. and 625 deg. C. on a sample of copper of "good conductivity":

$$\frac{\Delta l}{l_o} = (16.07t + 0.00403t^2)10^{-6}$$

Henning (96) has determined the expansion at low temperatures of the same material used by Dittenberger. He finds a contraction between 0 deg. C. and — 191 deg. C. of 2.917 mm. per 100 cm., which does not fit Dittenberger's formula.

Lindemann (97) finds Grüneisen's law, that the coefficient of thermal expansion / specific heat is a constant independent of the temperature, verified by determination

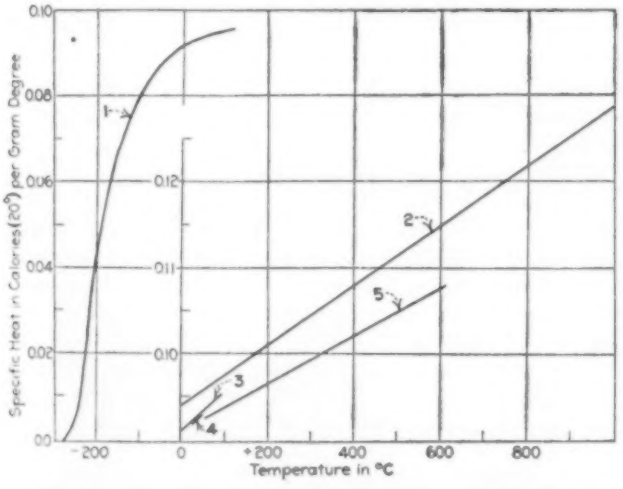


FIG. 13. EFFECT OF TEMPERATURE ON SPECIFIC HEAT (CONSTANT PRESSURE).

1. Nernst (102), electrolytic copper. Nernst & Lindemann (103). Keesom & Onnes (101).
2. Richards & Frazier (105).
3. Griffiths & Griffiths (99), electrolytic copper.
4. D. R. Harper (100), electrolytic copper.
5. Schübel (106).

of the expansion at low temperature. He finds

$\frac{1}{l}\frac{dl}{dt}$ from 85 deg. to 292 deg. (absolute) $= 124 \times 10^{-6}$

20 deg. to 80 deg. (absolute) $= 49 \times 10^{-6}$

80 deg. to 90 deg. (absolute) $= 75 \times 10^{-6}$

(*d*) *Specific Heat.*—The specific heat of copper is *not constant* but varies with the temperature. In Fig. 13 are given curves taken from various observers indicating the effect of temperature on the specific heat.

The results of determinations made at the bureau (100) show that between 0 deg. and 50 deg. C. the specific heat of copper, 99.87 per cent pure, of 100.5 per cent electrical conductivity (Mattheissen Standard), is a linear function of the temperature, and may be represented by the formula

$$C = 0.0917 + 0.000048(t - 25) \text{ — } \frac{\text{calorie 20 deg.}}{\text{gram. degree}}$$

This value agrees well with a probable value deducted from the results of many previous investigators.

Optical.—Copper is a metal, which takes a fairly high polish and reflects well. The reflecting power, the refractive and absorption indices are given by the curves

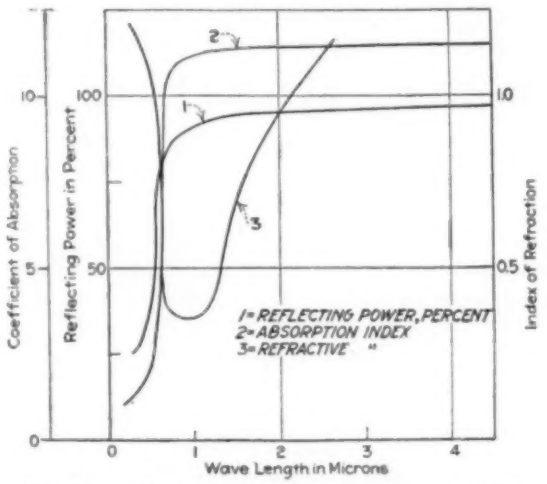


FIG. 14. OPTICAL CHARACTERISTICS OF COPPER

1. Reflecting power (perpendicular incidence) in per cent.
2. Absorptive index—K.
3. Refractive index—N.
Curve 1 from data by Hagen & Rubens (110, 111).
Curves 2 and 3 from data by Minor (113) and Ingersoll (112).

of Fig. 14. The selective absorption and reflection is strikingly indicated.

The relative emissivity of copper and of cuprous oxide at different temperatures as determined by various observers is given in Table I. The selective emissivity

TABLE I—RELATIVE EMISSIVITY OF COPPER

λ in Microns	1—Coefficient of Reflection. Hagen & Rubens (110, 111) 20° C.		Relative Emissivity. Stubbs (114)			Relative Emissivity. Tate (115) 20° C.	Relative Emissivity of Cu_2O Burgess (108) 1100° C.
	Electrolytic Copper	Commercial Copper	1090° C.	1127° C.	1174° C.		
.450	.512	.63	.....	.....	.....	.....	.....
.475	.....	.....	.374	.473	.....	.....	.....
.500	.467	.56	.374	.381	.402	.51	.68
.550	.405	.52	.330	.340	.349	.....	.....
.560	.....	.....	.....	.....	.....	.42	.....
.600	.165	.28	.210	.210	.197	.29	.....
.650	.110	.20	.148	.152	.146	.....	.60
.660	.....	.....	.....	.....	.....	.22	.....
.700	.093	.17	.106	.130	.124	.21	.....

Temperature, ° C.	Relative Emissivity for λ = .65 Burgess & Waltenberg (109)	Relative Emissivity for λ = .55 Burgess & Walternberg (109)	Relative Emissivity for λ = .66 Bidwell (107)
700	.....	.....	.11
930	.096 s	.....	.....
1025	.105 s	.....	.....
1080	.117 s	.38 s	.....
1100	.150 l	.36	.....
1200	.....	.....	.....
1400	.....	.....	.11
1800	.....	.....	.11
	.....	.....	.124

is clearly shown, the copper absorbing or emitting strongly at the blue end of the spectrum. According to Bidwell (107), Stubbs (114), and Burgess and Waltenberg there is no practical temperature variation of *Et* between 20 deg. and 1500 deg. C.

(*To be continued*)

Some General Aspects of Evaporation and Drying*

By HUGH K. MOORE

THE subject of Evaporation and Drying may be classified under six headings:

(1) Direct Evaporation or Single Effect (Pressure or Vacuum).

(2) Multiple Effect Evaporation.

(3) Air or Gas Drying.

(4) Radiant Heat Drying.

(5) Chemical Drying.

(6) Mechanical Drying.

The first is familiar to all of us, and is used, for instance, in boiling water in a teakettle or evaporating water as in the production of jelly or candy, etc., and is still done in the most primitive manner, namely, putting the substance into a sample shaped vessel and heating it by direct heat. In this we have the primitive steam boiler. The scope of this paper does not include either the history or the construction of the steam boiler, which was used as such by Hero, 150 B. C., for the production of power. We may, however, briefly consider the separation of two ingredients.

Direct Evaporation

Direct evaporation is used:

1. In cases where the amount of liquor is so small that it does not pay to have a multiple effect. An example of this is the evaporation of maple sap to make maple syrup, maple sugar, or candy, either under atmospheric pressure or vacuum.

2. In cases when the boiling points are so high that multiple-effect evaporation is not feasible; an example of this is the kettle process for caustic soda and caustic potash.

3. In cases where the liquor contains incrusting material, so that it is necessary to clean the tubes or pan very often. An example of this is the evaporation of salt brine containing calcium sulphate.

4. In cases where a certain sized crystal is desired. An example of this is the open drainer pan used in the salt industry.

5. In cases where the material to be evaporated is so corrosive that the materials required for the construction of the evaporator are too expensive to be used in anything but a single effect, of simple form. An example of this is to be found in the concentration of sulphuric acid, nitric acid, acetic acid, etc.

6. In cases where materials decompose at a high heat. Such an example is the production of concentrated coffee.

7. In cases where the object is to recover some volatile constituent. An example of this is the evaporation in the pot still. The evaporation in the column still is in this class, though it has certain features on the border line of the multiple effect.

8. In cases where the object is to obtain artificially a low temperature or a sudden chill. Both the absorption and compression systems of artificial refrigeration come in this class.

9. In cases either with or without vacuum, where the liquor to be evaporated is already a concentrated solution and its physical or chemical properties require that the final dried product be taken off as a film or powder or mass of crystals. Sulphite digester liquor is an example; this may be best handled in a rotary drum drier either with or without vacuum, according to the product one desires.

Direct evaporation in a vacuum is practised in nearly all the above cases, though not, as many persons seem to think, for economy of steam, but rather to secure the advantages of relatively low temperature. It is found that there is no great economy in direct evaporation under a vacuum over and above evaporation under atmospheric pressure, and none at all if the vacuum has to be produced by steam power.

Fig. 1 gives the values at different temperatures of the heat in a pound of water above 32 deg., the "latent" heat of vaporization, and the "total heat," or sum of the other two. Referring to Fig. 1, 1 lb. of steam at 212 deg. F. contains 1146 B.t.u. (above 32 deg.), while 1 lb. of steam at 134 deg., namely, under 25-in. vacuum, contains 1120 B.t.u. In other words, the pound of steam under 25-in. vacuum contains 97.73 per cent of the heat in a pound of steam at atmospheric pressure.

Multiple-Effect Evaporation

Multiple-effect evaporation is distinguished from single-effect in that the vapors evolved from a portion of the substance are condensed in a separated chamber by another portion of the substance, thereby giving up their latent heat to this other portion and liberating their equivalent in vapor from this other portion. Each such stage is called an effect. It will be seen that each effect acts simultaneously as a condenser and evaporator.

For instance, referring to Fig. 1, we find 1 lb. of steam at 242 deg. Fahr. contains 1161 B.t.u. in total heat, 950 B.t.u. in latent heat. Theoretically, if this steam heats water at 222 deg. Fahr., it should give up 971 B.t.u., evaporating thereby 1.007 lb. of water to steam at 222 deg. Fahr., having a total heat of 1154 B.t.u., and latent heat 964 B.t.u. per pound. This steam, in turn, could give an evaporation of 1.004 pounds of steam from water from and at 212 deg. Fahr. If we count also the available heat in the condensed water from the first effect we have 0.0103 lb. additional evaporation. In other words, in the double-effect operation as described we get 2.021 lb. of water separated from the liquor for 1 lb. of steam used. Now, the above figures are on a theoretical basis only. As a matter of actual practice, the evaporation in the above illustration would be a little lower, on account of the heat carried off in the drip, or condensed water, which would not be reduced quite to the temperature of the evaporated steam as was assumed in the illustration.

It will be seen that this operation can be repeated as many times as desired, provided only that a tempera-

*A paper read at the St. Louis meeting of the American Institute of Chemical Engineers, December 7, 1917.

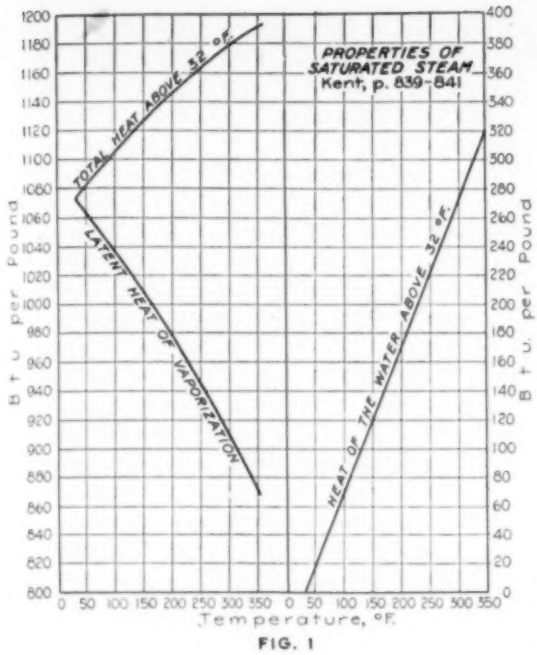

PROPERTIES OF SATURATED STEAM
Kent, p. 839-841
TOTAL HEAT ABOVE 32° F.
LATENT HEAT OF VAPORIZATION
HEAT OF THE WATER ABOVE 32° F.
B t u per Pound
Temperature, °F.

FIG. 1

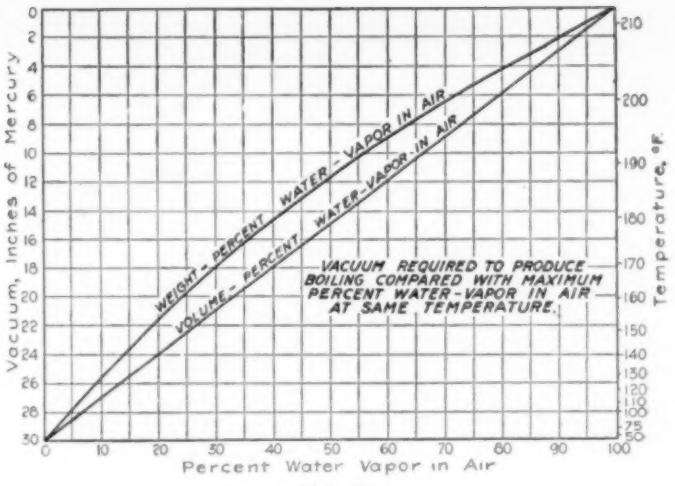

VACUUM REQUIRED TO PRODUCE BOILING COMPARED WITH MAXIMUM PERCENT WATER-VAPOR IN AIR AT SAME TEMPERATURE.
WEIGHT-PERCENT WATER-VAPOR IN AIR
VOLUME-PERCENT WATER-VAPOR IN AIR
Vacuum, Inches of Mercury
Temperature, °F.
Percent Water Vapor in Air

FIG. 3

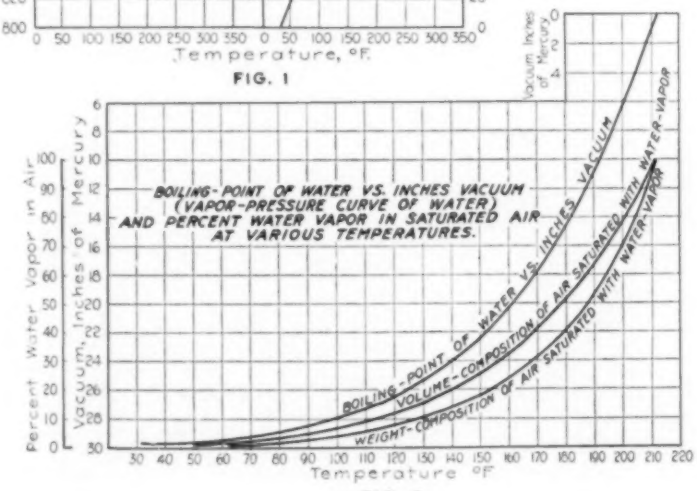

BOILING-POINT OF WATER VS. INCHES VACUUM (VAPOR-PRESSURE CURVE OF WATER) AND PERCENT WATER VAPOR IN SATURATED AIR AT VARIOUS TEMPERATURES.
BOILING-POINT OF WATER VS. INCHES VACUUM
VOLUME-COMPOSITION OF AIR SATURATED WITH WATER-VAPOR
WEIGHT-COMPOSITION OF AIR SATURATED WITH WATER-VAPOR
Percent Water Vapor in Air
Vacuum, Inches of Mercury
Temperature °F

FIG. 2

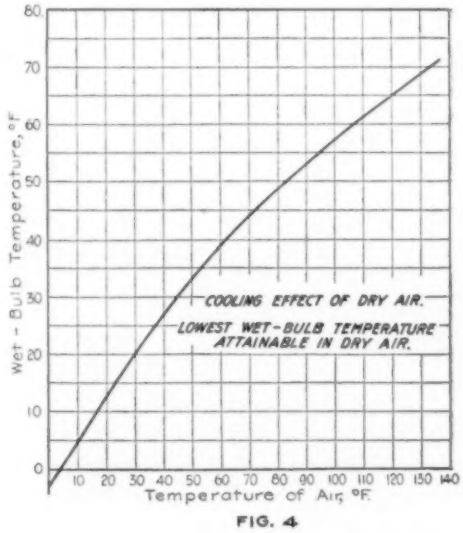


FIG. 4

ture difference is maintained between successive effects.

This, in brief, is the principle of multiple-effect evaporation. Later on in this paper the writer will explain a few of the intricacies of such evaporation.

The multiple-effect principle is used:

1. Where the amount of liquor to be evaporated is large.

2. Where the cost or concentration of the valuable ingredients is so small and the cost of fuel is so high that the evaporating cost is an appreciable item in the whole operation. As a matter of fact, multiple-effect evaporation is very seldom resorted to on a small scale, because the required constant attention of an expert evaporator man usually more than offsets the saving in fuel. Furthermore, the first cost of a small multiple-effect evaporator is all out of proportion to the work done.

Air Drying or Gas Drying

Air (or gas) drying is a method of evaporation in which the partial pressure of the vapor of the volatile constituent is kept less than the vapor pressure of the liquid by mixing with the vapor air, or other gas. In this case the pressure shown by a gage is the total pressure, or sum of the partial pressures of vapor and air.

Women know that they can dry clothes on a fine day even though the temperature be below freezing. They can also tell you that if the wind is blowing briskly the clothes will dry much more quickly. Here, then, you have a common case of air drying with which every one is familiar, though few could tell how it is possible. The curves on Figs. 2 and 3 show the vacuum required to produce boiling compared with maximum per cent water vapor in air at the same temperature. On this chart will also be found the relation to temperature. Thus, air at 187 deg. will take up additional water only if it contains less than 60 per cent by volume of water vapor, and water at 187 deg. boils only if a vacuum of 12 in. is exceeded. Then at 187 deg. air containing 60 per cent water vapor may be said to correspond to a 12-in. vacuum. At 195 deg., air containing 60 per cent *by weight* of water vapor corresponds to a 9-in. vacuum. Again, saturated air containing 10 per cent water by volume corresponds in temperature to 27 in. of vacuum (115 deg.). It will thus be seen that by decreasing the proportion of water vapor in the air the temperature effects of any desired vacuum can be obtained without the necessity of maintaining a real vacuum in a closed apparatus. A given volume of air, if maintained at a given temperature, can only evaporate a certain maximum amount of water (or other fluid), and this limit is only approached when the air has been brought into intimate contact with the substance to be evaporated,

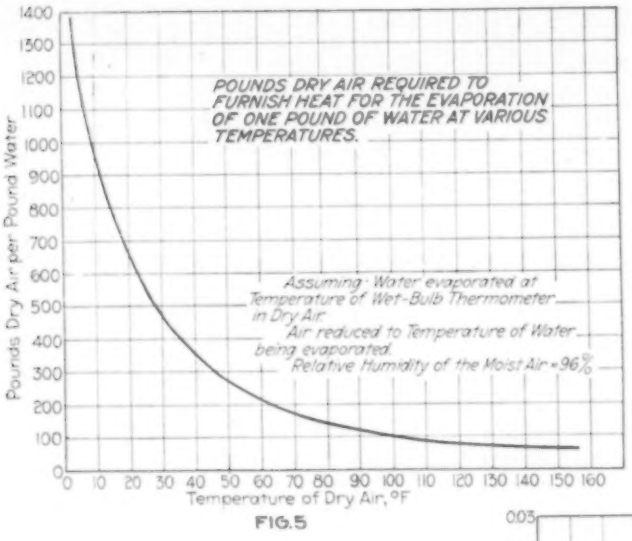

POUNDS DRY AIR REQUIRED TO FURNISH HEAT FOR THE EVAPORATION OF ONE POUND OF WATER AT VARIOUS TEMPERATURES.
Assuming: Water evaporated at Temperature of Wet-Bulb Thermometer in Dry Air.
Air reduced to Temperature of Water being evaporated.
Relative Humidity of the Moist Air = 96%
Pounds Dry Air per Pound Water
Temperature of Dry Air, °F

FIG. 5

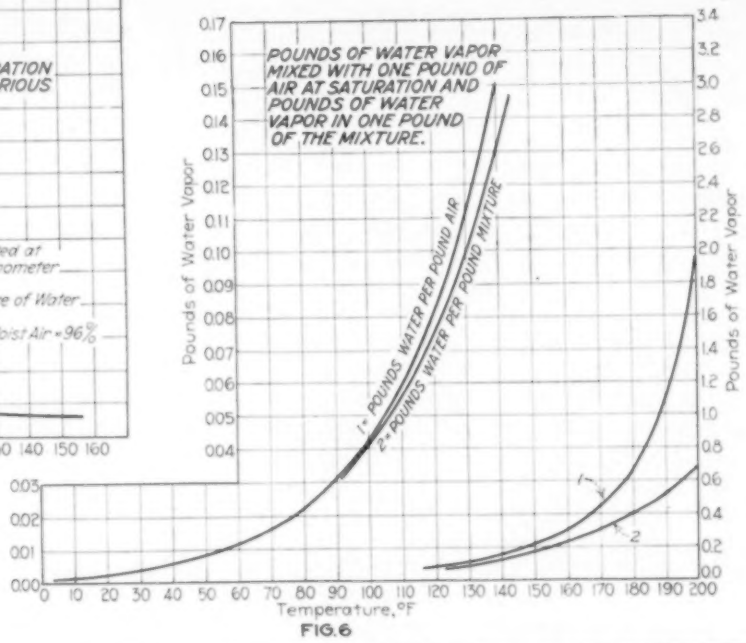

POUNDS OF WATER VAPOR MIXED WITH ONE POUND OF AIR AT SATURATION AND POUNDS OF WATER VAPOR IN ONE POUND OF THE MIXTURE.
1st POUNDS WATER PER POUND AIR
2nd POUNDS WATER PER POUND MIXTURE
Pounds of Water Vapor
Pounds of Water Vapor
Temperature, °F

FIG. 6

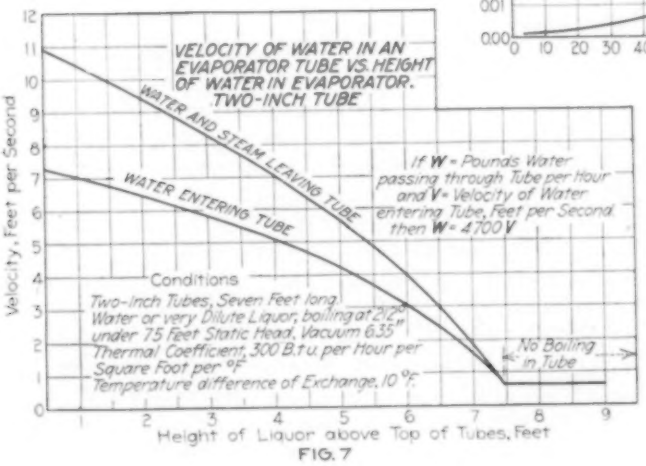

VELOCITY OF WATER IN AN EVAPORATOR TUBE VS. HEIGHT OF WATER IN EVAPORATOR. TWO-INCH TUBE
WATER AND STEAM LEAVING TUBE
WATER ENTERING TUBE
If W = Pounds Water passing through Tube per Hour and V = Velocity of Water entering Tube, Feet per Second then W = 4700 V
Conditions
Two-Inch Tubes, Seven Feet long. Water or very Dilute Liquor, boiling at 212° under 7.5 Feet Static Head, Vacuum 6.35" Thermal Coefficient, 300 B.t.u. per Hour per Square Foot per °F. Temperature difference of Exchange, 10 °F.
No Boiling in Tube
Velocity, Feet per Second
Height of Liquor above Top of Tubes, Feet

FIG. 7

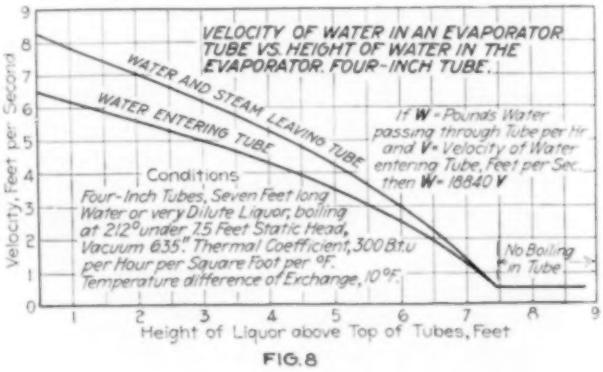

VELOCITY OF WATER IN AN EVAPORATOR TUBE VS. HEIGHT OF WATER IN THE EVAPORATOR. FOUR-INCH TUBE.
WATER AND STEAM LEAVING TUBE
WATER ENTERING TUBE
If W = Pounds Water passing through Tube per Hr. and V = Velocity of Water entering Tube, Feet per Sec. then W = 18840 V
Conditions
Four-Inch Tubes, Seven Feet long. Water or very Dilute Liquor, boiling at 212° under 7.5 Feet Static Head, Vacuum 6.35". Thermal Coefficient, 300 B.t.u. per Hour per Square Foot per °F. Temperature difference of Exchange, 10 °F.
No Boiling in Tube
Velocity, Feet per Second
Height of Liquor above Top of Tubes, Feet

FIG. 8

so that all parts become saturated. Of course, it goes without saying that the hotter the air and the drier the air the more rapid the evaporation. However, increasing the temperature of the air does not increase the temperature of the wet substance very greatly if the percentage of saturation is kept low enough. One pound of water requires about 1000 B.t.u. for its vaporization, whether it be evaporated under pressure or in a vacuum. Now, in every case the necessary heat must be supplied, either from the air, from the substance being evaporated, or by conduction to the substance being evaporated. It should be remembered that heat is relative, and things we consider cold may give up heat to things which are colder. It may be asked where the heat comes from that evaporates the water in clothes hung out to dry on a cold winter day, and what difference of temperature there could be. Perhaps this can be answered graphically by the curve of Fig. 4, which shows the cooling effect of dry air, based on wet and dry bulb-thermometer readings; also Fig. 5, showing pounds of dry air required to furnish heat to evaporate 1 lb. of water at various temperatures. Fig. 6 shows pounds of water per pound of air and pounds of water per pound of mixture when air is saturated at different temperatures. For example, Fig. 4 shows that with dry winter air at 30 deg. F., the clothes could drop to a temperature of 20 deg., and Fig. 5 shows that 470 lb. of dry air at 30 deg. would contain enough available heat to evaporate 1 lb. of water at 20 deg. Fahr. This assumes that the air is originally dry, and leaves saturated. If, however, the air is not dry, and does not leave saturated, a greater quantity is required. It will be seen that in this case the air furnishes the requisite heat for the evaporation. As a brisk wind moves a greater quantity of air past the wet surface, it will readily be seen that the evaporation must necessarily be more rapid. The temperature of the wet clothes will depend on the saturation and temperature of the air, but cannot go below the values of Fig. 4. Here in a simple illustration are all the fundamental principles of air drying.

The writer has been asked why we cannot take a sufficient quantity of air and dispense with artificial heat. We can, but if it costs more for apparatus and power to move and utilize this air than it would cost to supply the required heat we have gained nothing, and perhaps have the additional expense of conditioning or filtering the larger quantity of air.

From the above it will be seen that while air drying at an elevated temperature partakes in some respects of the advantages of vacuum drying, it may not be as economical in the expenditure of heat, inasmuch as heat has to be supplied to raise the temperature of the air, as well as to furnish heat for the evaporation of water (or other fluid).

Having briefly touched on the principles of air drying, let us see under what conditions it may be profitably employed:

1. The drying, at relatively low temperature, of a substance which is continually entering and leaving the apparatus. In this case it would be practically impossible to obtain a vacuum. An example of this is the drying of pulp, paper, cloth, etc., over hot rolls. Heat is supplied to the rolls, and the hot, moist sheet, leaving the rolls, passes through the air and is dried. The rapid evaporation keeps the temperature down to such a limit that the pulp or paper is not seriously affected by the heat. Here, continuity of process and nature and amount of the materials are the controlling factors.

2. The drying, at low temperatures, of substances whose internal structure must be preserved. Examples are eggs, wood, pulp, pipe, etc. In the first example, for instance, if eggs were evaporated in a vacuum, one would have an edible product; but owing to the rapid evolution of steam from the interior as well as the surface, the organic structure would be so destroyed that one could not make an omelet from the resulting product; while if the eggs are air dried by letting this moisture gradually diffuse to the surface, the resulting product can be beaten up and a fine omelet can be obtained. The drying of wood in such a manner as to avoid checking is a more familiar illustration, and need not be gone into here.

3. Where the final product must be in a fine state of subdivision, and heating, even for a short time, may destroy some valuable characteristics.

An illustration is the evaporation of milk to milk powder and eggs to egg powder; these substances cannot be kept even momentarily at a high temperature during evaporation without altering or coagulating. Here the milk or eggs are reduced to such fine particles that they are nearly all surface. When these particles come in contact with hot, dry air they part rapidly with their water, and this rapid evaporation prevents their reaching too high a temperature.

Mr. O. G. Soule of Merrill-Soule has kindly furnished me with the following information as to the evaporation and drying of milk:

The milk is first condensed in a vacuum pan until it contains approximately 33 per cent solids. This is done for two reasons: First, it is a cheaper method of evaporation than evaporation entirely by spraying into the air; secondly, the resultant product, when finally dried, has what is called a greater apparent specific gravity; that is, the powder is more compact, and in an equal volume will have a greater weight than the product obtained entirely by the air spraying. After evaporation under vacuum to 36 per cent solids, the product is sprayed—under pressure of between 3000 and 4000 lb. to the square inch—through a minute orifice, with the result that the milk is subdivided into very fine spheres. This product is sprayed into a drying chamber through which is passed a current of air heated to approximately 180 deg. Fahr. The small particles of the liquid are thus entirely suspended in this current of air in the shape of minute spheres, representing an enormous surface, and resulting in very rapid evaporation. The product, as it dries, falls to the bottom of the drying chamber, or is carried along with the current of air and collected outside the drying chamber by means of a dust collector of special design. Since evaporation takes place in the air entirely, the particle being evaporated is kept cool during the evaporation; while if evaporation takes place in contact with a heated metal surface the product, during evaporation, is itself heated, and the albumin of the milk tends to coagulate. In the Merrill-Soule method of drying, this cooling effect is obtained, and the product does not become heated until the moisture is substantially removed. The advantage of this is apparent from the fact that neither the vitamines nor the enzymes are materially injured by this process; neither is the albumin coagulated. When the milk powder is reconstituted with water they find the original bacteria becoming active, the enzyme action apparently unchanged, and the growth-promoting qualities still in their original form. This, so far as they are aware, is a result unobtainable in any other way. While the milk powder is in its dry state there is found no material action taking place on account of the bacteria therein. The bacteria do not multiply, but rather tend to decrease in the product due to the absence of moisture. On the other hand, when moisture is put back into the powder the bacterial action goes on as in the original milk, and a similar fermentation takes place as takes place in milk.

A similar process is also applied to the drying of eggs; the egg albumin is not coagulated, and is soluble in cold water.

As a matter of commercial practice, milk is pasteurized before drying, thus killing pathogenic bacteria, and practically the only bacteria left in the powder are of the lactic acid variety, which are, of course, harmless or useful.

4. Drying such substances as are not affected by heat, but are either sticky or poor conductors of heat.

Such, for example, is the process used in drying salt, lime sludge, or the black liquor made by the soda and the so-called sulphate processes for wood pulp. In the latter case, water is not only evaporated, but the residue is also charred so that it loses its sticky qualities; but as the object is the recovery of the soda base, this does no harm.

Drying by Means of Radiant Heat

The writer discussed radiant-heat drying at considerable length in a previous paper before this society,* and so has no need to go into it here; neither is the time at his disposal sufficient to warrant its discussion at this time.

Suffice to say that probably in the near future it will be used in concentrating many substances which require a high temperature for evaporation and where there is no suitable material of which to construct the types of apparatus now in use. It is now used for the evaporation of the so-called sulphate black liquor. It is thought that this process offers a great opportunity to solve the difficulties encountered in connection with the phosphoric acids.

Chemical Drying

The ability of certain chemicals to absorb water or other fluids is made use of in drying many substances, and the principles are so well known to the chemical engineers that we can dismiss the subject by giving a few illustrations. These fall into a natural classification according as the wet material is a gas, a liquid, or a solid.

1. Undoubtedly the most use is made of this principle

*See this journal Aug. 1, 1917, p. 117.

in drying gases. Here we have two vapors mixed which it is desired to separate. This mixture of gases is passed through a chemical which absorbs one and allows the other to pass through unchanged. Thus in the hydrogenation of oil, dry hydrogen is required. In this case the wet hydrogen is passed through concentrated sulphuric acid, where the moisture is absorbed. Most wet gases attack pipes of the ordinary materials, but if they are dried few if any have any action whatsoever. Chlorine, sulphur dioxide, hydrochloric acid gas, hydrogen, and hydrogen sulphide are examples of gas which are handled in large quantities in this manner.

2. Liquids are sometimes dried in the same manner as gases. An emulsion of oil and water may be separated by hydrochloric-acid gas. Mineral oils are dried by the use of sulphuric acid, and in cases where a trace of acid must not be left they are dried by the use of calcium carbide. In either case the oil comes out more or less dry. Chloroform is dried over calcium chloride or zinc chloride, as well as sulphuric acid.

3. Solids may be dried either by contact with an appropriate gas or by immersing in a volatile liquid, which, uniting with the substance to be removed, will pass off easily at a much reduced temperature. As an illustration of the first method we may take the drying of crystallized magnesium chloride. In ordinary evaporation this would break up into magnesium oxide and hydrochloric acid, but if dry hydrochloric acid gas is passed through it under pressure the drying will be accomplished and the decomposition largely prevented. Or again, according to the second method, magnesium chloride may be dried to the decomposition point and then mixed with amyl alcohol and the mixture evaporated. In this case, very little decomposition takes place if the amyl alcohol is in sufficient excess and the operation is done in a vacuum.

Again, butter fats may be dissolved from their water and other admixture by dissolving in deodorized rhigolene or cymogene and evaporating the solvent at a low temperature.

Mechanical Drying

This hardly comes within the scope of this paper, and will be dismissed by classifying and giving a few illustrations. Five fairly common means might be distinguished: 1, squeezing; 2, filtering; 3, centrifugal force; 4, heating; 5, refrigerating.

1. The hydrostatic press may be used to dry wet materials, as, for instance, in pressing the water from wood pulp, oils and water from seeds, and water from fabrics. The compression of a saturated gas reduces its capacity to hold water vapor at the same temperature, and effects a partial drying.

2. Filtering may be illustrated by the separation of lime sludge from caustic liquor in a filter press.

3. The centrifugal machine in most cases is simply a filter in which centrifugal force is substituted for hydrostatic pressure, though in some cases the centrifugal force is so applied that it merely accelerates the natural separation of two materials of different specific gravities.

As a filter, the centrifugal machine is used most in separating crystals from a mother liquor. Thus: in separation of salt crystals from caustic solutions, or sugar from its mother liquor.

Centrifugals are used in the other manner in separating oil from water, or in separating an emulsion of cotton-seed oil, water and soaps of the fatty acids; or in separating the oil emulsions encountered in steam-power plants.

4. Air at its dew point may be dried in the physical sense by heating it. This is done in heating ventilation, etc. Of course, chemically there is just as much water in the air after heating as before heating, and this is only a case of apparent drying.

5. Conversely, air may be caused to give up its moisture by refrigerating. This principle is made use of in the dry-blast process in the production of iron and steel. Sometimes a gas may form a compound with water, or other substance to be removed, and may be used to dry itself. Thus, if liquid chlorine is sprayed through moist chlorine gas, or liquid sulphur dioxide through moist sulphur dioxide gas, the liquid will vaporize, abstracting heat from water and gas, and the water will be precipitated in solid form in more or less loose combination with the chlorine or sulphur dioxide, as the case may happen to be.

Heat Conductivity Data

The subject of evaporation and drying, in the sense as used by chemical engineers, is indissolubly connected with the subject of condensation and the heat conductivity of the materials used in the construction of apparatus.

The data used for conductivity through the metal partitions, which we are interested in when it comes to the designing of an evaporator, is not the thermal conductivity of metals, as given by physicists, as the conditions are not the same as those under which the physicists obtained their data. For instance, the heat conductivity of copper is given as 500, that of iron 233, and that of lead 103, all in B.t.u. per square foot per inch thickness per degree Fahrenheit difference per hour. Now, as a matter of fact, this data is of very little use, if any, to the engineer who has the problem of designing an evaporator for a liquid of given properties. If you have an evaporator with iron tubes, in which water and steam are the fluids on the two surfaces of the partition, you will get a conductivity of from 200 to 250 B.t.u. during the first stages of the heating; but during the second stage, that is, when ebullition becomes rapid, the conductivity increases to 1000. Now, the iron has not changed in the slightest degree, but the latter apparent conductivity is from four to five times as great, showing that we must look for some other factor than the conductivity of the metal alone. The factor in this case is the movement of the molecules of water. Water not in motion is a very poor conductor of heat, but when new molecules are brought in contact with the heated surface the absorption of heat from the heated surface is very much increased. Practically speaking, then, the large factor of conductivity in this case is not the metal but the rate at which heat is conducted from the surface of the metal to the liquid, and this factor may be expressed in terms of velocity of the liquid. The writer has obtained a conductivity of 1200 B.t.u. per square foot per degree Fahrenheit difference per hour through lead pipe by increasing the velocity of the liquid flowing through it. Under these same conditions, copper tube did not increase the conductivity more than could be accounted for by experimental error. Iron may have an apparent

conductivity of 200 to 250 B.t.u. to water not in motion, but if melted sulphur is substituted for the water the apparent conductivity drops to 3 B.t.u. A familiar case of the above is an ordinary boiler tube, which, having air on one side and water on the other, may not conduct more than 3 to 6 B.t.u. per degree difference Fahrenheit. Also a horizontal tube with water on the outside and steam on the inside will not have the apparent conductivity if it is 10 ft. long that it has if it is 3 ft. long. Here the determining factor is the length of the tube. As the steam condenses we have an accumulation of water on the bottom of the tube, and the depth of this increases as the length; since water itself is a poor conductor, and is not in this case in rapid circulation, it does not transmit heat readily to the tube. In the case of vertical tubes, in which the liquor is on the inside, there may be varying factors. The diameter may or may not be an influential factor. As you increase the length of the tube you tend to increase the velocity of the fluid inside the tube. This tendency to increase the velocity is due to the increase of the unbalanced pressure between relatively cool bodies of liquor in other parts of the bath and the warmer column of liquid and vapor circulating upward through the tube. This acts in much the same way as increasing the height of a chimney increases the velocity of the hot gases in the chimney. The effect of increased height may be offset, however, by an increase in the diameter of the tube, since in tubes of equal length the surface increases as the diameter, while the volume increases as the square of the diameter. It can readily be seen that the volume is so increased by increasing the diameter that the increase in heating surface is more than counterbalanced by the increase in weight of the liquor to be heated. See Fig. 7 and Fig. 8. This is what happens in the large central tube in some evaporators, or the outside zone in other evaporators, a downward instead of an upward current being maintained. An increase in the height of a tube may not always increase the heat conductivity. If the diameter be so small and the length so great that all the liquor entering it is transformed into steam, then an increase of height will be a detriment.

Brown Co., Berlin, N. H.

(*To be continued*)

Symposium on Potash

A joint meeting of the New York Sections of the American Institute of Mining Engineers and the American Electrochemical Society was held on Jan. 24, at which qualified speakers reviewed our various resources and gave the status of industries now contributing to our potash needs. The speakers and their topics were as follows: Col. Allerton S. Cushman, Frankford Arsenal, Philadelphia, and Alfred H. Cowles, Potash from Silicate Rocks; Dr. Wm. H. Ross, Department of Agriculture, Washington, Potash from Kelp; Leslie H. Webb, Western Precipitation Co., Philadelphia, Potash from Cement-Kiln and Blast-Furnace Dust; Sidney J. Jennings, Potash from Alunite; Kirby Thomas, Potash from Saline Lakes; E. G. Spillsbury, Potash from Greensand. Production from all sources in 1917 may amount to between 15,000 and 17,000 tons in terms of 80 per cent KCl. Cement-kiln dust is a promising source and may yield 70,000 tons per annum.

The Effect of the War on Engineering Education

By C. R. Mann

THREE years ago most of us thought that a world war could not last long because, however much kings and kaisers might wish to continue, the banker would stop it. But the financiers have not come up to our expectations in this matter, and we have therefore been compelled, unwillingly perhaps, to recognize that money is not the ultimate measure of national strength. National credit is the result and not the cause of intelligent industrial production; the engineer, not the banker, is the real power behind the throne.

This fundamental fact now seems so simple and self-evident that it is rather hard to remember the time when we thought otherwise. But though the rugged outlines of this fact are now sharply silhouetted against the ruddy dawn of the new age, the details of its meaning are but dimly discernible through the haze of speculation over the significance of the struggle. Naturally the engineer is intensely interested in the development of the details of the picture, for on him devolves the duty of interpreting the coming conceptions in terms of materials and organizations of men. And if education makes men, engineering education must be the first to feel the thrill of the dawning day.

Three elements in the picture can now be plainly perceived. These indicate that the engineer is from henceforth vitally involved in the control of credit, in the interpretation of the daily news, and in the organization of industry and commerce to make goods cheap and men dear.

In performing the first of these new functions, the engineer becomes the partner of the banker to determine which projects are worthy of financial support and which not. As the engineering spirit is more and more infused into this dispensing of credit, public service rather than excess profit becomes the inspiration for enterprise; intelligence in production becomes the best security for loans; ability to deliver the goods becomes the sure basis of financial success; and the control of tools gradually passes from the hands of those who own them legally into the hands of those who can use them effectively.

Newspapers and periodicals already sense the expansion of the engineering spirit in the struggle to make the nation strong. The distribution of wheat, the supply of sugar, the transportation of coal and the price of bread are now subjects which occupy an amount of space in the daily press that only a Thaw trial could formerly command. The public has never before realized how vital and how interesting factories, freight cars, warehouses, terminals, trucks and ships really are. Some faint conception of the necessity of organization for the common project of liberating life by winning the war seems to be taking shape; while an impelling desire to serve and to subordinate personal preferences to community interests appears to be dimly developing. These faint feelings of fraternity may grow into driving impulses, if editors continue to extol engineering enterprise rather than private profit in their interpretations of the daily news.

In many communities chambers of commerce or groups of engineers have organized to build up business

and boom the town. Through their efforts living conditions have been improved and many a city is being made a better place for homes. But the progress has always been hampered by the vested rights of individuals and of corporations, so that none has yet dared to envisage an entire community as a single working plant for the purpose of organizing it for the most intelligent production of human wealth. This can now be done. The war is opening many hitherto blind eyes to see that each gains more than he loses when he merges his strength with the might of all in an organization that is constructed for the purpose of releasing creative energy by giving each the work he is best qualified to do.

The time has come for such an organization in every community and every state, because the Federal Government is struggling to shape the nation into an organization of this type. Only so may the nation be strong; only so may communities add their utmost to the nation's strength. The responsibility for this work must finally be shouldered by engineers who are both masters of the mechanic arts and moulders of men.

For many years this country has been drifting toward the realization of these requirements. The war has but accelerated the process and precipitated conclusions that were bound to come, otherwise men trained by experience to meet the present crisis could not now be found. Continuity demands that the same conclusions remain valid long after the war is ended. Therefore, engineering schools will render service in proportion as they grasp the implications of these conclusions and express them in the work of instruction.

The possible conclusions for engineering education are many and complex; but two stand out in bold relief, namely, there must be closer co-operation between school and industry, and there must be more attention to the appraisement of values and costs.

The essential feature of the co-operation with industry is not the skill, the knowledge of workmen, or the feel of the machines which the student acquires from shop experience. Important as these are, they cannot compete with the spirit of investigation which must develop if the co-operation between school and industry is real and vital. There are thousands of unsolved problems in even such rough shop work as freshmen are permitted to do. The boy should be trained to discover these unsolved problems and to bring them back to school for discussion and solution. By making shop work in industrial plants the source of problems for solution in school, and by relating the class and the laboratory work in some degree to the problems raised, conditions most favorable to the self-development of the student may be realized. As he progresses, the problems become more and more intricate, until in his last year, if he has shown real engineering ability, he may be assigned as helper in industrial research, either at the plant or in the school laboratories. After such a training in defining and solving problems, closely co-ordinated with instruction in science and drill in mathematics, he should be able on graduation to take a responsible position without serving several years as an apprentice, as is usual at present.

To the faculty this type of co-operation with industry brings incentives for creative work in production and in education. For co-operation makes the school the source of solutions of industrial problems, not only with respect to the technique of manufacture, but also concerning the correlation of the community's productive processes with the training of its citizens as intelligent workers. Hitherto manufacturing companies have stood aloof and regarded one another with suspicion—and the Federal Trade Commission discovered that 200,000 of them are not paying expenses; but now they are ready to co-operate. Similarly in education, many manufacturers are supporting corporation schools to train their own help, while more than half the children in the entire country quit school at the sixth grade without being trained to earn a living, but they too are now ready to co-operate. If the men who are teaching in engineering schools rise to the responsibility and organize for the systematic study of community production, they could soon create a true university, with its feet firmly planted in industry and its soul consecrated to the task of utilizing science and literature to liberate the creative energies of men.

While close co-operation between school and industry gives that practical experience which is essential for mastery of the mechanic arts, it is not in itself sufficient to enable the schools to meet adequately the fundamental requirements of engineering in the new epoch. The Germans are technically well trained in the mechanic arts, yet they are but brutally strong. In order to strengthen the nation by infusing the engineering spirit in the control of credit, in the interpretation of the daily news and in the organization of industry for the production of human wealth, the engineer must have sound judgment in the appraisement of values and costs. This requires not only an understanding of finance and the meaning of money, but also a sympathetic appreciation of the things humanity holds to be most worth while. Even a practical project like building a bridge is ultimately controlled by some man's decision that the resulting value is worth the cost; and this decision is more difficult and subtle when it concerns profoundly the production of human wealth and the appraisement of human values and costs. The engineer is too often obliged to be only the employee of the bank, the corporation, or the state commission, because he believed that engineering is wholly a matter of technical skill; when control in this, as in everything else, is really vested in the decision of the question whether the game is worth the candle.

Training in the appraisement of values and costs does not require the addition of formal courses for that purpose, but rather the injection of this point of view into every branch of school work. For example, experiments in chemistry need not always be of the type: Analyze this baking powder. The project: Make baking powder and find out if it is cheaper and better than any you can buy, is vastly more effective as a training exercise. Presented as a personal effort to appraise the human values and costs in life's experiences, literature fascinates engineering students. Economics delight them when it is a critique of proposed solutions of the social problems defined by their daily co-operation with labor. Such exercises also foster the development of those homely virtues, which always make the working people the bulwark of a nation's strength—the sense of justice, feelings of neighborly kindliness, devotion to right, and respect for God and man.

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Recovery of Spelter and the Treatment of Retort Residues

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IT IS customary at nearly all zinc smelters to make three draws of metal. The proportion drawn at each time is approximately as follows:

Smelting 50% Western Sulphide + 50% Leadville Calamine

	Charge	Blue Powder	Total
1st draw	22.7%	15.1%	37.8%
2d Draw	36.5	18.6	55.1
3d Draw	0.6	6.5	7.1
	59.8	40.2	100.0

Smelting Concentrates from Colorado Ore

	Charge	Blue Powder	Total
1st Draw	27.6%	10.2%	37.8%
2d Draw	35.2	15.0	50.2
3d Draw	5.0	7.0	12.0
	67.8	32.2	100.0

Smelting ⅔ Joplin Ore + ⅓ Leadville Calamine

	Charge	Blue Powder	Total
1st Draw	27.4%	10.8%	38.2%
2d Draw	34.4	14.5	48.9
3d Draw	6.3	6.6	12.9
	68.1	31.9	100.0

Smelting Straight Joplin Ore. Making Four Draws

	Charge and Blue Powder	
1st Draw	20%	2 top and 2 bottom rows
2d Draw	32%	whole furnace.
3d Draw	39%	whole furnace.
4th Draw	9%	whole furnace.

After establishing the percentage of each draw, giving the best recovery for a particular ore, the fireman may be instructed to so bring his furnace; but, as a rule, the proportion of metal drawn in no way controls the firing of the furnace.

Composition of Spelter.—Iron and lead are nearly always determined in the spelter, as they practically control its classification. Cadmium is occasionally required.

The following results on spelter made at different plants give some idea as to the per cent of these elements existing in the zinc, and shows the reduction in quantity of iron and lead in the spelter by the use of a front charge, either of coal or an ore low in iron and lead, the front charge being charged in the mouth of the retort. This, of course, increases the cost per ton.

Smelting a Colorado ore high in iron, and using the front charge, the following results were obtained:

1st Draw Charge		2d Draw Charge		1st Draw Blue Powder		2d Draw Blue Powder		3d Draw	
Fe%	Pb%	Fe%	Pb%	Fe%	Pb%	Fe%	Pb%	Fe%	Pb%
0.032	1.09	0.132	1.50	0.064	0.83	0.088	1.48		
0.016	1.03	0.110	1.60	0.050	0.92	0.080	1.48	0.35	2.18
0.020	1.09	0.076	1.59	0.06	0.97	0.072	1.39		

The general average, exclusive of third draw, would be Fe = 0.055 per cent, Pb = 1.20 per cent.

Smelting Joplin and carbonate ores low in Fe, with no front charge, all draws averaged Fe = 0.042 per cent, and Pb = 1.41 per cent.

Smelting a high iron ore with front charge, all draws average Fe = 0.061 per cent, and Pb = 1.31 per cent.

	Average 2d Draw Fe%
Not using front charge 4 days	0.089
Using a front charge 8 days	0.055
Reduction due to use of front charge	0.034

Smelting Joplin ore, average of charge and blue powder:

	Pb%		Pb%
1st Draw, 2 top rows	0.64	2 bottom rows	0.70
2d Draw, 2 top rows	0.88	2 bottom rows	0.79
3d Draw, 2 top rows	1.13	2 bottom rows	1.00
	0.88		0.83

Brass Special.—In using ores low in iron and lead it is sometimes possible to separate the first-draw charge and blue powder from the other draws, provided it does not make the latter too high in iron and lead. Spelter of the following analyses would probably pass for brass special: Fe, 0.03 per cent; Pb, 0.65 per cent; Cd 0.30 per cent.

Sampling Spelter

In order to obtain a sample representative of a lot or car of spelter a certain number of plates from each draw should be drilled and the drillings mixed, each draw to itself. Then from these samples aliquot parts (representing the weights of each draw in the lot or car) are thoroughly mixed, from which no less than 20 grams should be taken for a sample.

GRANULATED SAMPLE

Many of the plants are now having the fireman of the block take a small sample of the molten zinc from one or two ladles of each draw, just before molding. This should be poured from a height of several feet in as small a stream as possible, into a clean bucket containing clean water. The water is decanted off, the sample dried and transferred immediately to a clean pan or sack.

Such a sample will go into solution very rapidly, which is a decided advantage in controlling the iron and lead in the spelter. In taking a granulated sample, the chance of "salting" from the steel drill is also removed. The following test illustrates this: While the metal drawer at one of the plants was molding a plate of zinc the writer took thirteen samples from the stream. The plate was then drilled in thirteen places and all the samples were analyzed for Fe. The comparison is given in the accompanying table.

Controversies often arise between the producers and consumers of spelter with respect to the iron contents. In certain cases this may be due to "salting," but it is more apt to be due to the fact that four or even six draws, each with a different analysis in iron and lead, may be loaded into a car or piled into one lot for ship

Comparison of Analytical Results

No.	Percentage Iron—Drilled	Percentage Iron—Granulated
1	.084	.084
2	.048	.058
3	.122	.068
4	.110	.104
5	.072	.080
6	.096	.068
7	.072	.070
8	.104	.082
9	.062	.094
10	.068	.078
11	.094	.080
12	.084	.068
13	.084	.058
Average	.082	.077

ment. It would therefore be impossible for the buyer to obtain an accurate sample unless he sampled every plate, making a composite sample of all. It is interesting to note that while the third draw is only about 10 per cent of the total metal produced, it may actually contain as high as 50 per cent of the total iron in the spelter, and a large proportion of the total lead, as will be seen from the following example. Assuming 100 lb. of spelter produced, we have the following results:

	Total lb.	Percentage Fe	Percentage Pb	Pounds Fe	Pounds Pb
Draws exclusive of 3d Draw	90	0.055	1.20	0.050	1.080
3d Draw	10	0.350	2.18	0.035	0.218

Treatment of Retort Residues

General.—In view of the fact that a considerable proportion of the ores treated at the spelter works (primarily for the extraction of zinc) carry silver, gold, lead and copper, either singly or in various combinations, the proper method of handling the residues is one of considerable importance, and will probably be given more attention in the future than in the past.

The method of treating the residues not only varies at the different plants, but sometimes at the same plant, according to conditions and the analysis of the material. Whenever the residue is of such a value as to overcome the treatment charge, freight, etc., and leave a fair net profit per ton, it will, as a rule, pay better to ship direct without any attempt at concentration. If the residue, however, is too low in value to show any profit on direct shipment, some of the following means of concentration may be and are often adopted: dry screening, jigging, burning, smelting.

Dry Screening

This is the simplest and cheapest method of concentrating the residues, and often gives a very good grade of concentrate without much loss, provided the screen openings are not too fine. Under ordinary conditions a screen of No. 16 wire having 5 or 6 meshes to the linear inch is as fine as should be used. This size will remove only the clean, coarse coal or coke, provided the residue and fuel have in no way been sintered together during the process of extracting the zinc, or by permitting them to become wet or oxidized previous to screening. In either of the latter cases it would not pay to screen.

As previously stated, when the residue shows a direct profit it seldom pays to screen. A possible exception to this is where the lead runs just below 5 per cent, and is paid for as iron excess, or 10c. per unit. By screening through a screen just coarse enough the lead may be brought slightly above 5 per cent, and then be worth about 30c. per unit. Again, the lead in the blue powder residue will, as a rule, run as high as the lead in the charge residue. It may, therefore, occasionally pay to screen the blue powder residue and mix it with the charge residue.

Miscellaneous Screen Tests

No. 1

Using a 3-mesh screen 7/32-in. opening

Charge Residue

Mesh	Weight Lb.	Weight Tons	Per Cent	Analysis SiO_2	Fe	Zn	Sn	Pb	Ag	Au	Gross Value	Treatment, Freight, Etc.	Net Value
Charge Residue													
Plus 3	3819	1.91	32.3	13.3	10.0	6.0	3.8	2.5	7.8	0.16	$7.04	$5.70	−$1.34
Minus 3	8025	4.01	67.7	10.6	13.4	10.0	5.5	7.21	1.7	0.27	13.91	5.70	− 8.21
		5.92	Crude Residue=72%								$11.69	$5.70	$5.99
Blue Powder Residue													
Plus 3	1617	0.81	35.2	18.0	7.4	6.2	2.1	2.2	3.7	0.09	$2.80	$5.70	−$2.90
Minus 3	3008	1.50	64.8	11.1	9.4	8.7	3.8	6.2	6.7	0.14	8.16	5.70	+ 2.46
	4625	2.3	Crude blue powder residue=28%								$6.31	$5.70	$0.61

From the above figures it is apparent that it would not pay to screen the charge residue, while it would pay to screen the blue powder residue, as illustrated below:

2.3 tons per day per block at $0.61	$1.40
1.5 tons per day per block at 2.46	3.69
Difference per day	$2.29
On a 5-block plant per month	$345.00

The screening may be done by hand, but can be accomplished cheaper mechanically.

No. 2

Using a screen of 5-Mesh No. 15 Wire

	Analysis %	Ins.	SiO_2	Fe	Zn	Pb	Ag
Crude residue	100	27.5	18.0	20.9	4.0	6.1	10.5
Plus 5 mesh	26	32.8	22.8	14.8	2.8	3.4	7.0
Minus 5 mesh	74	25.4	15.0	22.2	4.5	7.0	12.0

No. 3

Using a screen of 5-Mesh No. 15 Wire

Crude residue	100.0	...	13.7	24.0	7.2	6.5	10.9
Plus 5 mesh	31.3	...	16.6	12.2	4.9	2.7	4.8
Minus 5 mesh	68.7	...	12.0	28.0	7.7	7.1	12.4

No. 4

Using a screen of 5-Mesh No. 16 Wire

Crude residue	100	...	13.8	24.7	7.0	2.5	10.4
Plus 5 mesh	36	...	15.0	15.2	5.0	1.8	6.2
Minus 5 mesh	64	...	13.0	30.0	8.0	3.0	12.8

No. 5

Using a screen of 6-Mesh No. 16 Wire

Crude residue	100	...	15.0	19.8	6.6	2.0	7.7
Plus 6 mesh	47	...	16.8	10.9	5.4	1.5	3.5
Minus 6	53	...	13.3	27.6	7.6	2.5	11.4

From such data as the above it is a simple matter to calculate the advisability of screening, and some idea is gained as to the screen best adapted, provided the results warrant the operation. The percentages on and through the screen, indicated as plus and minus, vary somewhat according to the degree of fineness of the charge fuel used in the furnace. In fact, the size of the charge fuel really governs the size of the screen opening.

Jigging Residues

Several plants have tried out the Harz type of jig on residues, but the success is very doubtful. At least the method has gone out of use at the plants of this country so far as the knowledge of the writer goes. One company has also tried out the Hancock jig, but judging from results, and records of the writer, and the fact that the method has not become adopted, it can hardly be considered satisfactory.

The results here submitted might be materially improved by the use of an automatic feed to the jig, and the further concentration of No. 4 hutch in some manner. Where the residue has been permitted to weather and oxidize, it is even still harder to effect a good separation. The first residue direct from the furnace gives a good grade of concentrate, but, due to the intimate mixture of the heavy fine slate in the coal and the fine ore, there is too much loss in the tailing. While the following results are not conclusive they give an indication of what may be expected.

The plant was designed and built to handle 100 tons per day, and consisted of the following equipment:

1 54-in., 80-hp. boiler.
1 52-in., 80-hp. boiler.
1 14-in. Blake crusher, 300 r.p.m.
1 set of rolls, 16 in. by 14 in.
1 main elevator to screen.
1 revolving trommel, 34 in. by 6 ft., with 6-mesh No. 16 wire, 18 r.p.m.
1 No. 4 centrifugal pump, 900 r.p.m.
1 4-compartment Hancock jig, 190 strokes per minute, ¼ in. vertically and 3/16 in. laterally, with following screen dimensions:
Hutch No. 1, 39¾ in. by 2 ft.
Hutch No. 2, 41¾ in. by 2 ft.
Hutch No. 3, 33 in. by 2 ft.

In addition to the above, a small Harz jig was later installed, with a view of separating the coal from the slate by handling the returns from the screen. While this separation was satisfactorily accomplished, the coal product ran considerably higher in ash than the original coal. As to the value of its reducing properties, the writer is not prepared to say. There is no doubt, however, that the plants in the United States will investigate this question further in the future.

General Operation

The residue was fed by hand into the crusher (through which a small stream of water flowed) and elevated to the revolving screen. The undersize was spouted to the Hancock jig and the oversize to the rolls. As previously stated, there was no automatic feed, and it was therefore difficult to keep the screens properly bedded at all times. Another difficulty encountered was the collecting of very small pieces of metallic zinc and iron upon the first screen bed, necessitating the frequent readjustment of the bedding over this particular screen. The cutting out of the oversize or taking it to the Harz jig for separation of coal simply transferred the trouble. The question, however, is not a serious one, provided careful work be performed on the furnaces.

Cost of Concentrating by Jigging

Based upon feeding 100 tons of crude residue to the Hancock jig per 24 hours.:

	Old Residue	New Residue
Two engineers	$5.00	$5.00
Two hutch men	4.00	4.00
Four feeders	8.00	8.00
One helper	1.80	1.80
Teaming	6.00	...
One blaster	1.75	...
One helper	1.50	1.50
Labor on pond	1.50	1.50
Water	2.00	2.00
Blasting materials	1.43	...
Repairs	1.68	1.68
	$34.66	$23.98
Cost per ton crude	0.35	0.24
Cost per ton conc.	1.05	0.72

Test Run No. 1

Fresh Charge Residue—Time 8½ Hrs.

	Percentage				Oz. Per Ton					Screens	
	SiO_2	Fe	Mn	Zn	S	Pb	Ag.	F.C.	V.M.	Mesh	Wire
Crude residue	11.0	29.7	0.84	5.5	3.1	3.4	5.4	...	..	...	..
Minus 5 M.	7.6	36.7	0.94	6.7	3.7	4.0	8.0	...	..	...	..
Hutch 1	5.6	58.9	1.06	7.0	4.0	5.8	11.0	...	..	6	14
Hutch 2	7.8	52.1	1.20	9.2	5.2	4.3	11.0	...	..	7	16
Hutch 3	18.6	31.1	1.00	7.7	4.0	2.8	9.3	...	..	6	14
Hutch 4	15.6	12.5	...	4.0	..	1.5	4.6	...	..	6	14
Tailings	13.2	7.4	...	3.0	..	0.7	3.6	...	..	...	..
Return to rolls	25.0	4.8	...	3.4	..	...	2.3	...	...	Ash	..
Coal material	....	2.7	...	..	0.7	...	...	70.8	2.0	27.2	..
Recovery %	.....	63.5	...	..	..	52.7	74.5	...	..	...	..

Weights and Values

	Dry Wt., Lb.	Value Per Ton	Cost Per Ton	Net Per Ton	Total Realization
Crude residue	61109	$5.11	$5.70	$0.59	$18.00
Minus 5-mesh	46076	7.58	5.80	1.78	40.94
Hutch No. 1	11250	...	...	...	....
Hutch No. 2	7260	...	...	...	....
Hutch No. 3	4640	...	...	...	....
Hutch total	23150	11.08	6.75	4.33	50.01
Hutch No. 4	8050	...	...	...	....
Tailing	21650	...	...	...	....
Slimes, etc.	8259	...	...	...	....

The above test shows that it would not pay to ship the crude residue, also a total difference between dry screening and concentrating of $9.07, or about 30c. per ton of crude residue.

Test Run No. 2

Fresh Charge Residue through ⅝-in. Trommel screen to Hancock Jig, Returned to Rolls Cut Out

	SiO_2	Fe	Pb	Ag	F.C.	V.M.	Ash	Screens Mesh	Screens Wire
Crude residue	8.5	25.9	5.0	8.7	....	....	....	....	....
Hutch No. 1	4.1	51.7	11.5	15.2	....	....	....	6	14
Hutch No. 2	8.8	37.7	6.3	12.6	....	....	....	7	16
Hutch No. 3	12.0	28.8	3.7	10.3	....	....	....	6	14
Coal	...	...	...	...	72.0	1.9	26	....	....
Recovery	.....	65.6	62.0	59.8	....	....	....	....	....

Weights and Values

	Wt.	Value Per Ton	Cost Per Ton	Net Per Ton	Total Realization
Crude residue	19,500	$8.03	$5.70	$2.33	$22.71
Hutch 1	4,671				
Hutch 2	1,862				
Hutch 3	659				
Hutch total	7,292	14.70	6.35	8.35	29.98
Coal	6,680				

The above shows a total difference of $7.27, or about 75c. per ton of crude in favor of jigging.

Test Run No. 3

Fresh Charge Residue Screened through 6-Mesh No. 16 Wire to Hancock Jig

	SiO_2	Fe	Pb	Ag	F.C.	V.M.	Ash	Screen Mesh	Screen Wire
Crude residue	9.5	20.8	2.7	5.4	....	....	....	....	....
Hutch 1	5.8	57.0	5.5	9.6	....	....	....	7	14
Hutch 2	15.2	35.0	3.1	9.9	....	....	....	7	16
Hutch 3	18.4	21.1	2.8	6.4	....	....	....	7	14
Hutch 4	....	....	....	....	41.6	1.4	57.0	½ 5	14
Recovery	.....	93.1	69.4	72.2	....	....	....	⅓ 7	18

Weights and Values

	Wt.	Value Per Ton	Cost Per Ton	Net Per Ton	Total Realization
Crude residue	66,000	$4.22	$5.70	$1.48	$48.84
Hutch 1	16,244	....	....	....	....
Hutch 2	8,136	....	....	....	....
Hutch 3	3,235	....	....	....	....
Hutch 1 and 2	24,380	10.50	6.75	3.75	45.75
Hutch 4	16,432	....	....	....	....

In this case it would certainly pay to concentrate. Hutch No. 4 would be of no value. In general, it was found impossible to obtain a good coal product from the Hancock jig.

Test Run No. 4

Blue Powder through ½-in. Screen to Hancock Jig

	SiO_2	Fe	Pb	Ag	F.C.	V.M.	Ash	Screen Mesh	Screen Wire
Minus ½ in.	13.6	13.6	5.5	5.3	....	....	....	....	....
Hutch 1	12.4	29.2	13.8	11.3	....	....	....	7	18
Hutch 2	19.0	25.9	9.6	10.0	....	....	....	7	18
Hutch 3	23.8	16.9	5.8	6.5	....	....	....	7	18
Hutch 4	21.0	9.6	3.2	4.0	....	....	....	½ 7	18
								½ 5	14
Coal	....	....	....	....	57.3	2.2	40.5	....	....
Recovery	.....	54.9	58.8	54.2	....	....	....	....	....

Weights of materials not recorded, but it would probably pay to concentrate.

TEST RUN NO. 5

Blue Powder through 5-Mesh to Hancock Jig—77.7%

	SiO_2	Fe	Zn	Pb	Ag	F.C.	V.M.	Ash
Minus 5-Mesh	16.6	14.5	7.2	−5.8	7.5	....	....	....
Hutch 1	6.0	37.8	12.0	−16.3	15.5	....	....	....
Hutch 2	12.2	33.4	11.8	13.3	14.8	....	....	....
Hutch 3	24.0	19.8	10.4	8.7	10.0	....	....	....
Hutch 4	19.0	8.7	4.4	3.4	4.6	40.5	0.8	58.7
Coal	11.4	6.2	....	....	....	56.6	4.5	39.0
Returns	16.2	....	....	....	....	56.5	1.1	42.4
Orig. Coal	10.3	2.2	....	....	....	66.6	7.5	25.9
Recovery	....	45.5	....	52.3	41.5	....	....	....

Weights and Values

	Wt.	Value Per Ton	Cost Per Ton	Net Per Ton	Total Realization
Through 5-Mesh	56,600	$5.73	$5.70	$0.03	$0.85
Hutch 1	6,840				
Hutch 2	2,440				
Hutch 3	3,372				
	12,652	13.77	5.66	8.11	51.33
Coal	14,000 (approximately)				

There is a decided advantage in concentrating, which is mainly due to the increase in the per cent of lead, which increases its value per unit, and a lower treatment charge.

TEST RUN NO. 6

Blue Powder Residue from Very Fine Leady Ore, Hancock Jig

	SiO_2	Fe	Zn	Pb	Ag	Screens Mesh	Screens Wire
Crude residue	10.1	12.7	5.8	8.7	6.3	....	....
Hutch 1	7.3	26.8	11.8	28.6	18.0	6	16
Hutch 2	10.8	27.8	11.0	19.2	14.6	7	18
Hutch 3	18.1	22.5	9.0	13.1	10.6	7	18
Hutch 4	21.0	14.2	5.8	8.0	6.5	....	....
Slimes	....	....	....	7.1	....	....	....
Recovery	....	37.3	33.8	44.3	43.0	....	....

Weights and Values

	Wt.	Value Per Ton	Cost Per Ton	Net Per Ton	Total Realization
Crude	46,160	$6.60	$5.70	$0.90	$20.79
Hutch 1	3,290				
Hutch 2	2,585				
Hutch 3	2,600				
Hutch total	8,475	17.37	4.73	12.64	53.47

A total difference in favor of concentrating of $32.68, or $1.41 per ton of crude, although the recovery is low.

This class of material could not be concentrated by dry screening, owing to its sintered nature.

The general conclusions drawn by the writer from the preceding tests are: First, that when the crude charge residue shows an appreciable net value it will not pay to concentrate by the Hancock jig; second, that the blue-powder residue seems to concentrate better, and may pay to jig, whether it shows a net value or not in the crude; third, that the fresh residue concentrates much more satisfactorily than the old or weathered residue.

With respect to the last test, Hutch No. 4 probably could be further concentrated by means of tables, vanners, or otherwise. While it would not be considered good practice to retreat Hutch No. 4 over the jig, the following test indicates that the jig may be overloaded, and that an automatic feed to same might improve the results.

HUTCH 4 REJIGGED

	Wt.	SiO_2	Fe	Zn	Pb	Ag
Crude	12,800	17.8	21.5	5.5	3.0	6.8
Hutch No. 1	720	11.4	31.5	10.5	6.7	10.5
Hutch No. 2	400	10.8	32.5	9.6	5.3	11.0
Hutch No. 3	440	12.0	29.5	8.8	4.0	9.3
	1,560					

This recovery looks very good, but owing to the incompleteness of the test no definite conclusions can be drawn. In fact, all of the tests made upon Hutch No. 4 material merely indicate the difficulty of further concentrating same.

SCREEN TEST ON OLD RESIDUE AFTER PASSING SCREEN OF NO. 16 WIRE, 6 MESHES PER LINEAR INCH

	Oz.	% of Crude	Insol. %	Insol. % Crude	Fe %	Fe % Crude	Zn %	Zn % Crude	Pb %	Pb % Crude	Ag %	Ag % Crude
Crude	156	....	20.4	....	24.3	....	7.0	....	5.77	....	8.5	....
Plus 10 mesh	36	23.0	22.8	25.8	14.8	14.1	6.0	20.0	1.9	7.7	5.0	13.6
Minus 10 mesh	40	25.6	21.4	26.9	19.1	20.2	4.7	17.2	3.0	13.5	6.5	19.6
Minus 18 mesh	36	23.1	18.6	21.7	24.4	21.9	5.8	19.2	5.3	21.5	8.5	23.1
Minus 40 mesh	24	15.4	16.4	12.4	31.0	19.7	7.2	15.9	6.6	17.8	10.5	16.7
Minus 80 mesh	12	7.7	16.4	6.2	31.0	9.8	7.8	8.6	7.2	9.8	10.6	9.6
Minus 100 mesh	3	1.9	16.4	1.6	31.7	2.5	8.6	2.4	8.2	2.8	11.3	2.6
Minus 150 mesh	6	3.8	15.8	3.0	30.9	4.9	8.8	4.9	7.7	5.2	11.0	5.0
	157	100.5	..	97.6	..	93.1	..	88.2	..	78.37	..	90.2

TEST RUN ON RESIDUE

Sutton, Steele and Steele Table, Coarse Top

	Lb.	Crude	SiO_2	Fe	Zn	Pb	Ag	Au	S
Head	291	....	10.0	24.5	4.0	tr.	5.2	.01	2.0
Concentrate	121	41.6	2.6	50.0	7.2	2.4	8.2	.02	3.4
Middling	13	4.5	20.4	10.6	3.6	0.7	3.6	.01	2.7
Tailing	124	42.6	10.9	2.4	0.6	....	0.7	tr.	....
Recovery on conc.	....	....	85.2	74.8	....	65.6	....	....	....

Magnetic separator test on material from Hutch No. 4, from Hancock jig treating old residue. Tests made upon the magnetic separator gave a high degree of concentration with respect to the iron, but the lead and silver were inclined to remain with the tailings.

WILFLEY TABLE TEST ON HUTCH NO. 4 MATERIAL

	Wt. Lb.	%	Insol.	Fe	Zn	Pb
Crude	93	....	27.5	18.7	5.4	2.5
— 20 + 24	..	....	26.4	17.9	4.3	2.3
Conc.	2	13.3	23.7	26.4	12.3	5.7
Tail	13	86.7	30.5	16.2	4.9	2.0
— 24 + 60	..	....	25.6	18.7	4.6	2.1
Conc.	14	33.3	24.0	29.1	7.0	3.9
Tail	28	66.7	28.0	14.4	3.5	1.6
— 60	..	....	26.2	21.0	5.9	2.9
Conc.	9	25.7	13.9	33.6	12.0	6.5
Tail	26	74.3	31.0	18.7	5.1	2.0

Recovery Pb = 52% Fe = 42.5

SCREEN TEST ON HUTCH NO. 4 MATERIAL

	Oz.	% of Crude	Insol. %	Insol. % Crude	Fe %	Fe % Crude	Zn %	Zn % Crude	Pb %	Pb % Crude	Ag Oz.	Ag % Crude
Crude	77	..	29.0	...	26.0	..	7.4	..	3.4	..	8.5	..
Plus 10 mesh	12	15.6	37.4	20.2	23.0	14.0	6.4	13.5	2.8	13.1	7.0	12.9
Minus 10 mesh	20	26.0	35.0	31.4	23.2	23.0	5.8	20.4	2.5	19.2	8.0	24.6
Minus 18 mesh	20	26.0	24.4	22.0	27.3	27.5	7.4	26.0	3.4	26.2	9.4	28.9
Minus 40 mesh	12	15.6	18.8	10.3	30.0	18.0	9.6	20.2	4.4	20.4	10.0	18.5
Minus 80 mesh	3.4	4.4	17.4	2.7	29.6	5.0	10.5	6.3	4.9	6.2	9.6	5.1
Minus 100 mesh	2.3	3.0	17.0	1.8	30.3	3.5	10.6	4.2	5.5	5.0	9.5	3.4
Minus 150 mesh	1.9	2.5	16.0	1.4	30.3	4.0	11.4	3.9	6.6	5.0	11.5	3.4
	71.6	93.7	..	89.8	..	95.0	..	94.5	..	93.4	..	96.8

Burning Residues

A certain degree of concentration may be obtained by burning the carbonaceous material contained in the residue, or at least the greater proportion of it. There are two special advantages gained by this method aside from the concentration, namely: the removal of the carbonaceous material, which is a detriment in smelting, and the sintered form of the product, which enhances its smelting value due to its mechanical condition and reduced dust loss in smelting. One of the zinc plants has had this method in practical use for some time. The residues are simply piled out upon the ground, over pipes or channels through which a blast of air is forced after the ignition has been started, the burning process being kept up until the greater part of the carbonaceous material has been consumed. The

blast is then turned off and the pile allowed to cool, after which it is broken up, loaded into cars, and shipped. The advantages of the process undoubtedly overbalance any metal losses.

Smelting Residues

A great many tons of residue containing precious metals have been smelted during the past 12 years at the various lead smelters, using a small proportion of residue mixed in with the general charge. Only one attempt, however, has been made in this country to smelt the residues as the principal burden of the charge. This experiment was made about 1903, at one of the zinc company's plants.

As there is a difference of opinion regarding the best method of treating the residues, the writer herewith gives his personal notes upon the above mentioned experiment, and a deduction of what might possibly be done under more favorable circumstances, with a view of arriving at a comparison between smelting and other processes of concentration.

Notes from Smelting Experiments

The furnace was only 36 in. by 90 in. at the crucible and 14 ft. from center of tuyeres to feed floor. The furnace being small, and a high per cent of zinc on the charge, it had to be let out frequently to bar off the accretions, the longest run being about six weeks.

Average Percentage Analysis of Materials Smelted

	SiO_2	FeO	CaO	MgO	ZnO	Al_2O_3	S	Pb	Cu	Ag	Au
Mo. iron ore	10.0	65.0	..	..	..	..	..	..	..	..	..
Lime rock	1.5	..	52.0	..	..	..	..	..	..	..	..
Mo. galena	1.5	2.4	..	..	9.5	..	11.0	74.0	..	..	..
Av. of ore beds	50.8	16.2	..	..	4.6	..	3.3	9.1	..	..	..
Residue	10.5	38.5	..	..	18.0	..	4.8	2.2	1.0	10.0	.03
Rst. matte	9.0	48.0	3.0	..	10.0	..	4.0	9.9	3.0	21.0	.06
Barrings	18.8	24.4	5.0	..	14.5	..	6.0	25.4	..	13.0	.07
Coke ash	27.0	28.4	14.5	4.5	..	19.7	..		..	..	..

	H_2O	V.M.	F.C.	Ash	S
Coke	1.2	2.3	85.7	11.1	0.9

Analysis of Products

	Bullion		Slag						Matte			
	Ag	Au	SiO_2	FeO	MnO	CaO	ZnO	Pb	Ag	Ag	Au	Pb	Cu
Feb.	90.1	1.15	31.2	35.9	1.0	14.5	10.3	0.88	0.98	19.0	.04	8.7	1.5
March	93.1	1.63	31.3	37.2	1.0	13.9	11.1	0.71	1.30	21.0	.06	8.0	2.5
April	104.3	1.59	29.8	37.7	2.7	13.9	11.4	0.52	1.40	23.0	.07	7.0	3.5
May	90.0	1.24	30.0	37.3	2.2	14.1	9.3	0.86	1.10	25.4	.07	5.1	4.0
July	78.7	1.00	32.2	37.4	1.0	13.9	9.8	0.50	1.15	21.3	.03	8.9	4.0
August	90.8	1.21	31.2	37.1	1.7	13.7	9.6	1.10	1.60	23.1	.08	9.8	3.0
Sept.	65.3	2.58	32.0	39.7	0.8	14.9	8.1	0.80	1.30	18.6	.06	7.8	2.3
Av.	87.5	1.49	31.1	37.5	1.5	14.1	10.0	0.77	1.26	21.6	.06	7.8	3.0

Average Record of Furnace Operations for the Above Seven Months

Oz. Blast	Tons Per Fur. Day	% of Pb. on Chg.	% of Coke	% Matter Produced	% Saving Ag	% Saving Au	% Saving Pb
19.0	45.6	9.1	13.0	7.2	90.8	92.4	92.0

While the office record showed a loss of about $2,000 per month, it was due not so much to the metallurgical failure to smelt the residues as it was to the small size of the furnace and the high percentage of zinc left in the residues at that time; also to the high minus margin on the Missouri galena, due to the conditions under which it was bought.

The period of the experiment was 273 days, while the actual furnace days were only 149. The results are, therefore, no criterion of what may be accomplished under more favorable conditions.

To anticipate what may be accomplished under more favorable conditions, and reduce the above results to a fairer comparison with other methods of treating the residue, it is not unreasonable to assume the following:

1—Per cent of zinc in the residue, 7 instead of 14.
2—Due to this, a slag lower in iron could be run, thereby replacing some of the Missouri iron ore with residue.
3—Larger furnace, treating 100 tons per day, at a less cost per ton.
4—Furnace down only 28 days out of the 273.

Results Actually Obtained Based Upon 149 Furnace Days

	Per Day	Per Fur. Day
Labor and overhead expenses	$71.00	$117.20
Sampling and assaying	2.30	4.18
Supplies	2.00	3.72
Repairs and renewals	4.90	9.00
	$80.20	$134.10

	Tons Per Day	Minus Margin		
Galena	2.8	× — 6.05 =	— 16.94	
Lime rock	6.5	× — 1.09 =	— 7.09	
Iron ore	6.7	× — 4.25 =	— 28.48	
Coke	6.1	× — 8.20 =	— 50.02	
	— 22.1			— 102.53
				— $236.63

		Plus Margin		
Residue	13.3	× + 9.34 =	124.22	
Ores	12.2	× + 3.76 =	44.87	
	25.5			+ 169.09
Loss per day				— $67.54
Loss per month				$2,026.20
Loss per ton of residue				— $5.07

Results Upon Assumed Basis

	50 Tons Per Day	100 Tons Per Day	Per Fur. Day
Labor and overhead expenses	$71.00	$83.50	$89.40
Sampling and assaying exp.	2.30	4.60	4.95
Supplies expenses	2.00	4.00	4.28
Repairs and renewals expenses	4.90	5.80	6.21
	$80.20	$97.90	— $104.84

	Tons Per Day	Minus Margin		
Galena	5.6	× — 6.05 =	— $33.88	
Lime rock	14.0	× — 1.09 =	— 15.26	
Iron ore	9.0	× — 4.25 =	— 38.25	
Coke	12.2	× — 8.20 =	— 100.04	
				— 187.43
				— $292.27

		Plus Margin		
Residue	30.00	× + 9.34 =	+$280.20	
Ores	24.4	× + 3.76 =	+ 91.74	
				+ $371.94
Profit per day				+ $79.67
Profit per ton of residue				+ 2.66

The comparison between smelting and shipping the residue direct would be as follows:

	Total Margin Per Ton of Residue	Cost Per Ton of Residue	Net Per Ton of Residue
Smelting	$12.40	$9.74	$2.66
Shipping	8.10	5.70	2.40

If the residue was dry screened it would show a better profit than above. It is therefore very doubtful if it will pay to smelt the residues, except under the most favorable circumstances, or when they do not constitute the bulk of the charge.

The above comparison is based upon a residue of the following analysis and valuation:

Analysis

SiO_2, 10.5%; Fe, 32.7%; Pb, 2.3%; Ag, 10 oz., and Au. .03 oz. per ton.

Valuation

Smelting	*Shipping*
Market Ag = 59c. per oz.	Ag = 59c. per oz.
95% of Ag.	95% of Ag.
$19 for Au @ 92%.	No pay for Au.
90% of Pb @ 3c. per lb., less refining.	10c. per unit for Pb.
10c. per unit for excess iron.	10c. per unit for excess iron.

The Filter-Press

By D. R. Sperry

PERHAPS no machine employed in the chemical industry at the present day is so little understood and at the same time so widely used as the filter-press. Beyond a doubt this is due largely to the great variety of ways in which the machine is used. Persons who are in intimate contact with filter-presses as used in their particular branch of the chemical industry are informed regarding them only as arranged and used in their process. They know very little of the hundred and one other arrangements in which the filter-press can be used and is used in other chemical processes. General knowledge of the filter-press, therefore, is not likely to be found among the actual users of the apparatus. The lack of general information regarding it in text-books and in technical publications, due probably to the reasons given above, produces a lack of information on the subject among those who are not already users. It is quite probable that there are a great many instances in chemical processes wherein the filter-press could be used to advantage were it possible for engineers and chemists to obtain a broad general understanding of the device. It is the writer's purpose to convey by means of this article a general knowledge of the filter-press, and it is his earnest hope that it may prove an efficient tool for engineers and chemists in solving their problems.

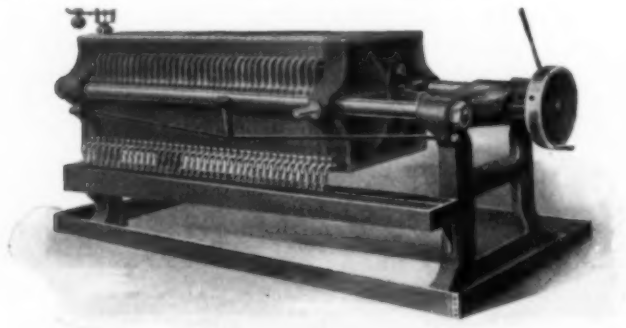


FIG. 1. FILTER-PRESS

Field of the Filter-Press

The field of the filter-press is very broad, which explains its great versatility, inasmuch as it may be used wherever the great principle of the separation of solids from liquids is employed. There are very few cases indeed in the various branches of the chemical industry where it is not necessary in some way to separate solids from liquids. In most of these lines, not all, to be sure, the filter-press may be used. Its field extends also to a certain extent into that of lixiviation and extraction, as will be explained later.

What the Filter-Press Does

The filter-press does two important things, namely:

(a) Separates solids from liquids.

(b) Washes, lixiviates or extracts.

The first is performed by forcing or pumping the liquid containing the solids through a filter-base, usually cotton duck, thus retaining the solids in the cells or chambers of the filter-press. The liquid flows away, usually through cocks placed on each cell. The second process, called washing, consists in forcing water or some other liquid into the filter-press in such a way that it flows through the deposited solids, displacing therefrom the liquid contained in the pores which may later be recovered from the wash. Sometimes the wash water dissolves some desirable substance in the cake or solids, permitting its recovery later.

The filter-press can also cause thorough precipitation of a substance contained in the liquid by reason of the intimate contact which the liquid necessarily makes with the solids, causing the precipitation, as it passes through the cake.

The filter-press may separate solids from liquids, maintaining the process at some desired temperature. Thus a substance can be chilled and crystals filtered out, or a substance crystallizing at ordinary temperatures can be filtered hot in order to remove impurities and not crystals.

Commercial Uses of the Filter-Press

Some of the commercial uses of the filter-press are the following:

(a) Making dull liquids clear and sparkling for appearance sake only, as in cider, near-beers, liquid soaps, etc.

(b) Removing substances from liquids for re-use or which would injure the product if allowed to remain, as in removing Fuller's earth or bleach from lard,

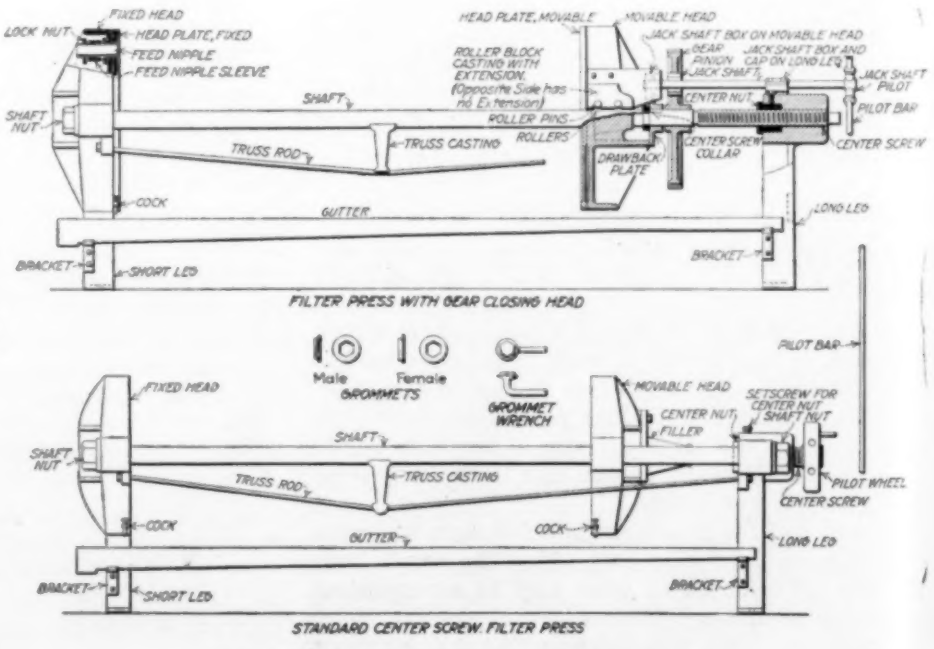


FIG. 2. NAMES OF PARTS OF A FILTER-PRESS

nickel from hydrolized vegetable oils, lime from sugar juices, etc.

(c) To separate a valuable liquid from a mass and then dissolve out or lixiviate some valuable substance contained in the solids, as in the treatment of cyanide slime in gold metallurgy.

(d) To separate a valuable mass from a liquid and then to lixiviate the valuable portion of the mass, the liquid being used solely as a conveyor for the mass, as lixiviating ground quartz in gold metallurgy after it has been deposited in the press by means of water.

(e) To reduce a muddy mass to a more convenient form, as in sewage sludge, china clay, etc.

(f) To save fuel in evaporation by removing the greater part of the moisture in the filter-press, as in the manufacture of lithopone, white lead, etc.

(g) To aid precipitation by mixing a substance causing precipitation with the liquid and pumping the mixture in a filter-press, as in gold metallurgy where zinc-dust is added to cyanide solution and is fed into a filter-press, the intimate contact of the cyanide solution causing gold to precipitate as it flows through the cake of zinc-dust.

(h) To crystallize out a substance which at ordinary temperature is liquid, by filtering in a refrigerated filter-press at which temperature crystals form, as in filtering certain oils.

(i) To clarify a substance which at ordinary temperature is crystalline, by filtering in a steam-jacketed filter-press at a temperature too high for crystals to form, as in Glauber's salts, where hydroxide of iron is removed.

(j) To separate a solid from an unstable liquid in a closed-discharge filter-press where the liquid does not come in contact with the atmosphere, as in certain varnishes and in cases where the liquid evaporates easily, as alcohol.

Advantages of the Filter-Press Over Other Forms of Filters

The advantages of the filter-press over other forms of filter are as follows:

(a) Includes the greatest amount of filter area per unit of floor space.

(b) Cost of filter area per square foot the lowest.

(c) Lowest cost of maintenance and repairs.

(d) Lowest operating expense due to the fact that common labor can operate a filter-press.

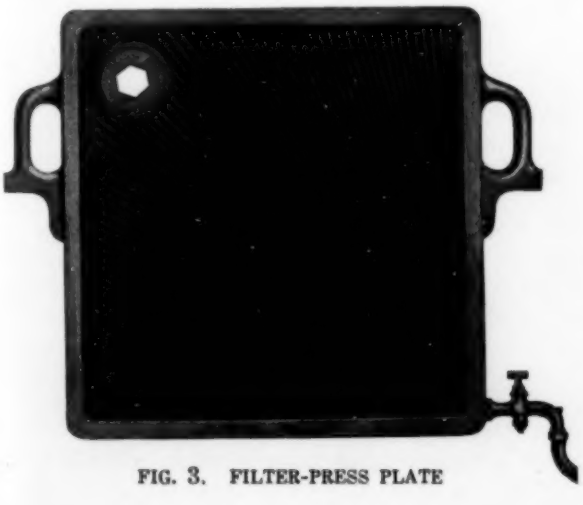


FIG. 3. FILTER-PRESS PLATE

At this point it is well to show what a filter-press looks like, and for that purpose there is shown in Fig. 1 a much used type. Cursory examination shows that it is a machine consisting of two general parts, namely, a screw-press supported on legs and a number of plates resting on the bars of the press and held together between the heads. Minor attachments consist of a row of cocks and a gutter. This machine is a filter-press in one of its most simple forms.

Definition of a Filter-Press and a Popular Misconception

A filter-press is a press which is employed to hold together the component parts of a filter.

A popular misconception of the name "filter-press" is that it is a machine which both filters the solids out of a mixture and squeezes or presses the solids as well. Many also imagine that a filter-press is some kind of a hydraulic press after the order of oil presses which squeeze the oil from seeds. The definition given above tells us that the filter-press is a press which presses a filter, just as a letter-press is a press that presses letters, or a hay-press is a press that presses hay. It should be remembered that while a filter-press presses a filter, it does so only to hold the filter together and not to press the solids within the filter.

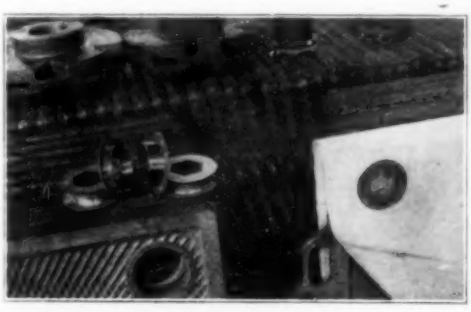


FIG. 4. FILTER-PRESS GROMMETS

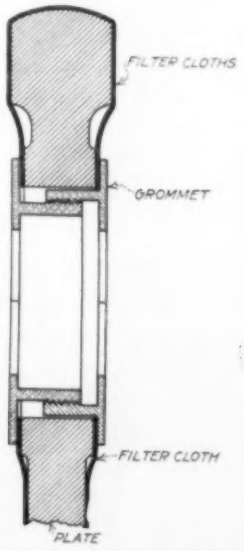


FIG. 5. SECTION THROUGH PORTION OF FILTER-PRESS PLATE SHOWING POSITION OF GROMMET WITH FILTER CLOTH IN PLACE

Names of Parts of the Filter-Press

In Fig. 2 are shown the names of parts of a filter-press both with and without gears for closing. It is quite interesting to note the great variety of names which users of filter-presses have given to the various parts. This is to be expected, of course, as up to the present time there has been no way of properly determining the correct names of parts. For example, the small parts called grommets, used to hold the canvas to the plates, have been called lock-nuts, cloth holders, flanges, ferrules, clamps, etc. Such a multiplicity of terms leads to confusion, and, therefore, in this article the names of parts given in Fig. 2 will be used exclusively.

Filtration Without Frames

The simplest form of filtration in a filter-press is that in which recessed plates are used. In Fig. 3 is shown a recessed plate with grommet screwed in place. To use these plates, they are first "clothed"; that is, a piece of the filter-base, usually cotton duck, is cut long enough to lay over the top of the plate and cover both sides. A hole is cut in the cloth on each side of the plate where it covers the grommet hole, and the grommet is applied. In Fig. 4 is shown the grommet hole

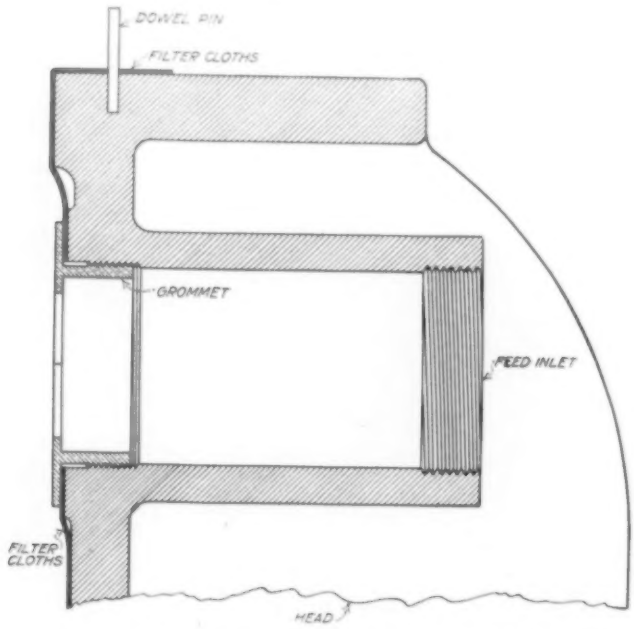


FIG. 6. SECTION THROUGH PORTION OF FIXED FILTER-PRESS HEAD SHOWING HALF-GROMMET AND FILTER CLOTH IN PLACE

in a plate (left-hand side), three grommets, one of which is unscrewed (left center of picture) and a grommet in place with cloth properly applied to plate (right side of picture). The grommet when thus screwed in place holds the cloth tightly down against the finished portion of the plate surrounding the grommet hole. A cross-section through the grommet hole when thus in place is shown in Fig. 5. The surface of both of the heads of the filter-press is similar to that shown on the plate in Fig. 3, except that on the movable head there is no grommet hole. A cloth is thrown over the surface of each head and a hole cut only in the cloth on the fixed head where it covers the grommet hole. A half-grommet, usually the male part, is screwed into the grommet hole of the fixed head, thus holding the cloth to the finished surface, surrounding the same in a manner similar to that done in the plates. A cross-section of a portion of the fixed head through the half-grommet is shown in Fig. 6. There are usually provided two dowel pins on the top of the heads, by means of which the cloth can be kept from falling down. This can be noted in Fig. 6.

When all the plates and heads are thus clothed, the plates are placed within the filter-press. A cross-section through the filter-press and plates when this is done is shown in Fig. 7. A study of this cross-section will disclose the fact that when the plates and heads are clothed as described there is formed throughout the length of the press a number of cells or chambers between each plate and between the heads and the adjacent plates. It will further be observed that all of the cells thus formed are connected together in multiple by means of the openings through the grommets. In fact, the grommets form a continuous channel running from head to head and joining together all of the chambers formed by the recessed surfaces of plates and heads. If now the screw of the filter-press is tightened so as to strongly compress the plates and heads together, the cloth covering the finished border of the plates and heads acts at that point as a packing, making the cells nearly watertight. It is interesting to note that there are two thicknesses of cloth at the joints, making a very thorough packing. Suppose now that a mixture of solids and liquid is introduced at the inlet of the fixed head. The result will be that the mixture will run the whole length of the press along the channel formed by the grommets filling all of the chambers or cells. If the mixture is placed under pressure there is but one thing which can happen, namely, the liquid of the mixture will flow through the cloth which bounds the chambers, while the solids will be left and may ultimately completely fill the chambers. The liquid, as it emerges from the back side of the cloth, comes into contact with the surface of the plate and is conducted by means of grooves, see Fig. 3, to one of the corners, where it

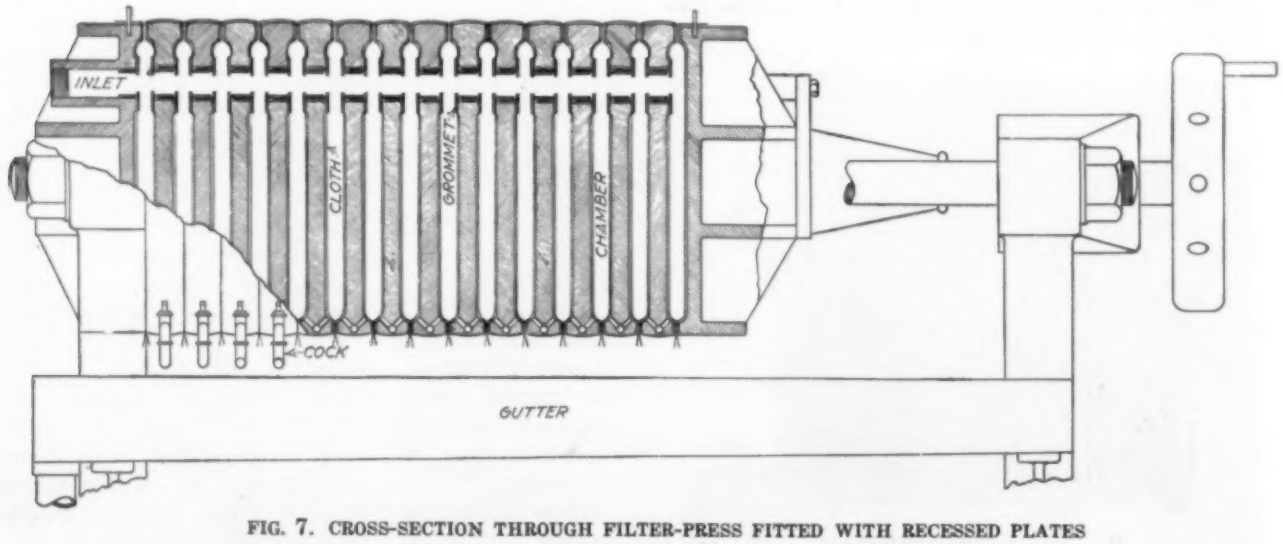


FIG. 7. CROSS-SECTION THROUGH FILTER-PRESS FITTED WITH RECESSED PLATES

flows into a small hole that leads to a cock placed on the corner of the plate. From the cock it empties into a gutter, from whence it is piped to a suitable receptacle. When the chambers become filled with solids or when the flow of liquid has become very small, the pressure is removed from the entering mixture and the screw of the filter-press is loosened so that the plates may be separated from one another. This is accomplished by pushing back the slide head as far as it will go and then pulling back each plate one by one, removing the solids as each one is brought forward. When the solids have thus been removed the plate which was last drawn up is slid back to the fixed head, the workmen seeing that the last traces of solids are removed from the cloth packing surfaces. Similarly, each plate is successively drawn back and inspected, until the movable head is reached, when it too is drawn back into place. Pressure is then applied to the screw and the filter-press is ready to receive another lot of the mixture. In the hands of the laborers who are accustomed to the work the process of removing the solids is not so long a process as one might suppose. The writer knows of a case where filter-presses containing forty plates have been opened, the solids removed, and closed again in an average time of fifteen minutes. Two common laborers perform the operation with ease.

NOMENCLATURE

Now that the simplest form of filtration in a filter-press has been described, it is well at this time to give the technical terms applied to the various steps in the operation as follows:

Clothing the Press.—Putting cloths on the filter-plates.

Closing the Press.—Squeezing the clothed plates together in the filter-press.

Filling the Press.—Pumping or otherwise forcing the mixture to be filtered into the filter-press.

Opening the Press.—Relieving the pressure on the screw of the filter-press and spreading the plates apart, at the same time removing the solids.

A Complete Cycle is the term applied to the successive operations of closing, filling and opening.

Cake means the solids deposited within the filter-press.

Filtrate.—The liquid issuing from the filter-press.

Batavia, Ill.

New York Section Société Chimie Industrielle

The organization meeting of the New York Section of the French Society of Chemical Industry was held at the Chemists' Club, New York, Friday evening, Jan. 18. As a result of a previous mail inquiry, about 150 chemists signified their intention of joining the new section.

The following officers were elected: L. H. Baekeland, chairman; Jerome Alexander, vice chairman; George F. Kunz, treasurer; C. A. Doremus, secretary. The council comprises Charles Baskerville, Henri Blum, M. T. Bogert, C. F. Chandler, Ellwood Hendrick, W. H. Nichols, R. E. Orfila, G. E. Valabrigue, E. P. V. Verge and Henri Viteaux. Following the election of officers a formal meeting was held, at which provision was made for election of the charter members. Dues were set at $7 per annum, and the date of the first meeting was announced as Feb. 15 in Rumford Hall, Chemists' Club.

M. René Engel, secretary of the parent society in France, was present and announced that the society would begin in February to publish its new journal, *Chimie et Industrie.*

Ordnance Department Needs Civilian Workers

The Ordnance Department of the Army urgently needs several thousand civilian workers, as specified in the following lists:

7700 clerical positions, including stenographers, typewriters, production clerks, statisticians, etc. Positions pay from $1,000 to $1,800 per year.

TESTING POSITIONS

200 engineers of tests of ordnance material, $1,500 to $2,400 a year.
200 assistant engineers of tests of ordnance material, $1,000 to $1,500 a year.

MECHANICAL TRADES POSITIONS

2500 machinists, $4.00 a day.
500 machine operators, $2.75 a day.
200 drop forgers, $5.75 a day (piecework).
300 tool makers, $4.50 a day.
Large numbers in practically all other trades.

DRAFTING POSITIONS

500 mechanical draftsmen, $800 to $1,800 a year.
50 gauge designers, $2,000 to $3,000 a year.
100 apprentice draftsmen, $480 a year.

INSPECTION POSITIONS

300 inspectors of small-arms ammunition, $1,500 to $2,400 a year.
100 inspectors of artillery ammunition (high-explosive shell loading), $1,500 to $2,400 a year.
100 inspectors of artillery ammunition (forgings), $1,500 to $2,400 a year.
100 inspectors of artillery ammunition (ballistics), $1,500 to $2,400 a year.
300 inspectors of field artillery ammunition steel, $1,500 to $2,400 a year.
300 assistant inspectors of field artillery ammunition steel, $3.50 to $5.00 a day.
500 inspectors of small arms, $1,500 to $2,400 a year.
100 inspectors of material for small arms, $1,000 to $1,800 a year.
100 assistant inspectors of cannon forgings, $1,500 to $2,400 a year.
100 assistant inspectors of finished machine parts, $1,500 to $2,400 a year.
100 assistant inspectors of gunfire control instruments, $1,200 to $1,500 a year.
50 assistant inspectors of steel helmets, $1,000 to $1,800 a year.
50 assistant inspectors of cleaning and preserving materials, $1,000 to $1,800 a year.
400 inspectors and assistant inspectors of powder and explosives, $1,400 to $2,400 a year.

For further information apply to the representative of the United States Civil Service Commission at the post office or custom house in any city, or to the Civil Service Commission in Washington, D. C. Except for the positions of stenographer and typewriter, typewriter operator, multigraph operator, and general clerk, applicants are not assembled for a written examination, but are rated principally upon their education, training and experience, as shown by their applications and corroborative evidence. The positions are for men only, except in the clerical work, where women are also accepted.

Intensive Toluol Production—I

Proposed Improvements in the Absorbing and Stripping Process

By FRANK E. LICHTENTHAELER

IT may be safely stated that a sufficient supply of toluol will prove a prime factor in determining our success in the war. However manifest this may be, the plain fact that the supply is inadequate, and the immediate need of meeting the situation aggressively and in a well-directed manner, do not appear to be comprehended to the full extent demanded by the exigency. This does not fail to take account of existing plans for increasing the supply, but refers more directly to an observed tendency to think in terms of the present only; and if one may judge from information published to date, the main issue, an unfailing supply of toluol, is hopelessly obscured by repeated descriptions of some particular process and incidental apparatus without evidence of a clear understanding of basic principles involved, yet with an air of finality that does not seem warranted on any sound engineering ground. Unessential details have been painfully emphasized to the exclusion of the broad underlying facts that, after all, will determine the eventual degree of success. A comprehensive plan of procedure founded on a scientific analysis of the situation seems to be lacking.

War Requirements

It has been stated that 22,000,000 gallons of toluol must be forthcoming by September, 1918, to supply an army of one million men. It is conceded that ultimately we may have four or five million men in the field and presumably the toluol production must increase proportionately. Published figures seem to account for approximately 12,000,000 gallons in addition to the present output from coke ovens, most of the latter already being taken by the navy. Yet the strongest accompanying statement is that "it is interesting to note that this is more than half the amount required." The significant point escapes emphasis: Where, definitely, is the other half?

Our Government is developing a wonderful machine for the creation of a vast trained army, the all-sufficient power of which will insure victory and a real peace. An equally efficient machine must be developed simultaneously to supply the endless quantities of munitions and materials from which they are made, and at a rate far in excess of the army's immediate needs. This is the greatest task for those of us who stay behind, and if we fail we have betrayed our brave men who are going with complete confidence that we will do our part as they do theirs.

The undoubted urgency of these matters would seem to warrant a broad survey of the situation in the hope of arriving at some elastic plan of procedure capable of extension to meet demands far beyond to-day's limited vision. At a time of great stress it is inadvisable to attempt a nice calculation of quantities of essential supplies that are likely to be needed. Sound judgment warrants the assumption that ultimately we may have to provide ourselves and our Allies to an extent far exceeding all possible forecasts. Our plans, therefore, must contemplate a large excess of all essential materials. An overproduction will be forgiven as mere insurance, protecting present and future generations. A shortage will doom us to almost certain defeat and the shame of having failed those who go to bear the brunt of battle.

The purposes, then, of this article are threefold:

First: To warn against delay in providing an unlimited supply of toluol. All available resources, great and small, should be developed simultaneously, not gradually in order of their importance only as the need becomes more pressing. The estimated deficiency must come from new and undeveloped sources, such, for instance, as the cracking of petroleum in excess of the normal requirement for carburetting purposes; and there must be a liberal reserve anticipating the invariable error of underrating ultimate needs.

Second: To advocate more simple and economical methods of toluol production, that our financial and material resources may be conserved to the utmost. Specific recommendations along this line constitute the main subject matter of this article.

Third: To emphasize the costly mistake of our Allies, if we may judge from observations in Canada, in respect to wholesale waste of toluol in the process of munitions manufacture. If we can but bring ourselves to foresee the likelihood of a similar condition in our own munitions factories, much could be done in the way of remedying or preventing needless loss of this essential material and the incidental cost and labor attending its production.

Development of Resources

With this attempt to state the fundamental proposition and with a strong desire to contribute toward a more rational means of meeting its terms, we proceed directly to suggest specific recommendations in respect to improved methods of toluol production. Reviewing briefly the question of supply, there are three main sources usually referred to:

1. Coke-oven gases.
2. Illuminating gases.
3. Cracked petroleum products.

In respect to the first source, the utmost pressure should be brought to bear in the matter of new by-product coke-oven installations, including equipment for treating the gas and tar for maximum yield of toluol and benzol. These installations require considerable time, and the comparatively few available companies, experienced primarily in the intricacies of by-product oven construction, should have their efforts directed and concentrated on a rapid and unlimited development of this field. This alone constitutes a task, the accomplishment of which is of no less importance than the exten-

sive ship-building program of the United States Shipping Board. Certainly the experience and manufacturing capacity of these same concerns should be fully utilized in respect to recovery and refining apparatus required in connection with by-product oven installations. It should not be too quickly assumed, however, that their very creditable progress in respect to recovery methods and apparatus has reached the same high plane of development that applies to their work in connection with coke ovens. It stands to reason that other American concerns, who have made a life-work of solvent recovery and refining problems in the same sense that coke-oven manufacturers have specialized on coke-oven practice and with equivalent progress in the development of their knowledge and skill, may likewise have important contributions to offer pertaining to advance progress in recovery and refining methods not included in the usual scope of gas engineering and evidently unappreciated by specialists in coke-oven practice. We hope to show later that a very material improvement is possible along these lines—a highly desirable improvement if it helps to reduce the practice to one of greater simplicity and higher economy.

Turning next to the third source mentioned above, namely, cracked petroleum, we believe this will ultimately become of great importance. After all of the gas works have contributed their utmost, it will probably develop that the output alloted to by-product coke-oven plants cannot be increased with sufficient rapidity to span the gap, in which case it would appear necessary to turn to the cracking of petroleum, because considerable information is available on the subject and the necessary equipment could be provided within a comparatively short time. Certainly this possibility should be anticipated, and if the growing coke-oven supply cannot be depended upon except for remote needs, work should be started immediately along the lines of petroleum cracking, especially as this appears to be a source capable of unlimited development. In this connection it is desired to mention work done by the Standard Oil Company in producing benzol and toluol from California crude oils. It is our belief that developments in this quarter have passed beyond the experimental stage, making it possible perhaps to estimate a dependable future output. We have built apparatus for producing "toluol pure" from the crude light-oil mixtures resulting from cracking California oils, and sincerely believe that it is a field offering possibilities that cannot safely be overlooked.

Source two, above, namely illuminating gases, absorbs our main attention for the present, principally because it offers a large available supply that can be made to yield results most quickly. Besides it is realized that the carburetting of water-gas is essentially a petroleum cracking process, with the great advantage that hundreds of plants are available, requiring merely the addition of suitable recovery apparatus. This article deals mainly with the situation in respect to source two—the recovery of toluol from illuminating gases. We recommend a comprehensive and simultaneous recovery applying to carburetted water-gas, coal-gas and oil-gas, including their respective tars. The same procedure that we will suggest would apply also to sources one and three, above. This should be borne in mind in connection with a broad study of the entire situation with the purpose of simplifying and increasing the efficiency of recovery methods as applied to whatever source. That is to say, recommendations that may appear pertinent to illuminating-gas recovery methods might also be expected to improve the economy of recovery from oven gases and all other sources, as well.

The simultaneous working of all toluol-yielding sources, as suggested, raises the question of how to handle the many cases involving associated and inseparable paraffins in an excess of 2 per cent, which has been set as the limit above which the toluol is claimed to be unfit for explosive purposes. There stands against this claim, however, an equally authoritative statement to the effect that upward of 10 per cent inert paraffins does not interfere with subsequent nitration, at the same time suggesting the separation of the paraffins from the mono-nitro product by simple distillation. This latter claim may have been disproved, but we find no information to this effect. Is it not more likely to be a case of prejudice on the part of munitions manufacturers who have been long accustomed to insist on "toluol pure"? Now toluol containing 10 per cent of inert material is essentially "toluol pure," and it should be very definitely determined whether or not mere reluctance to add a simple and inexpensive distilling operation, coupled with characteristic bias in favor of antiquated methods, is the sole explanation and reason for casting aside a substantial amount of toluol that can ill be spared. The oft suggested plan to so carefully control the carburetting processes as to keep the paraffin production below 2 per cent would appear to be a far more difficult undertaking than minor modifications in the established practice of munitions manufacture.

The Absorbing and Stripping Process

It may not be amiss at this point to establish a reason for selecting the so-called "absorbing and stripping" process to the exclusion of other methods. We recommend this procedure notwithstanding the fact that we hold basic patents covering solvent recovery from gas mixtures by means of combined compression and refrigeration. This latter process is practically and extensively employed in connection with the recovery of gasoline from casing-head gas, and we might be supposed to have a prejudice in its favor. The "absorbing and stripping" process, however, lends itself in every way to existing conditions at gas plants throughout the country, and the same applies to by-product coke-oven installations and the few existing petroleum-cracking plants. The compression and refrigeration process, unfortunately, requires the use of very large and expensive compressors and expanding engines, and the procedure involved is so radically different, more difficult and dangerous than comes within the experience of the industries to be dealt with that every conceivable argument for employing this process appears to be disproved. So far as we know, there are no other practical methods that might be employed, so we are certainly justified in concentrating efforts on a general betterment of the so-called "absorbing and stripping" process.

We propose to treat this subject under four main headings, namely: Absorbing, Stripping, Concentrating and Refining. Part one of this article refers more particularly to improvements in absorbing and stripping, leaving discussion of the remaining two sub-divisions to be covered by part two to follow. This division of the

subject is suggested by the fact that all gas works will be interested in absorbing and stripping, but whether or not they will engage in concentrating and refining of the light oil is an important point in question which also we will leave for later discussion.

Lummus Absorption System

We have endeavored to conceive an ideal procedure and accompanying apparatus to fit existing conditions in both large and small plants, insuring maximum economy of production and least demand on the facilities, skill and financial resources of the gas manufacturer. In fact, this same problem under slightly different aspect was presented to us as far back as July, 1913, in connection with the recovery of wood alcohol from its vaporous mixture with the fixed gases of charcoal by-product ovens. We devised a method at that time which formed a nucleus for our subsequent development of the so-called Lummus system of recovering the condensable constituents of vapor-gas mixtures. The original conception was not put into practice because it represented a departure from usual methods employed at wood chemical plants and we were unable to overcome the prejudice in favor of long-established practice, although wasteful and illogical. However, more recent developments in connection with petroleum cracking gave us the much hoped for opportunity to crystallize our ideas on this subject and definitely design and build plants on a commercial scale.

FIG. 1—ABSORPTION SYSTEM OF SOLVENT RECOVERY FROM FIXED GASES

Accompanying Fig. 1 illustrates the general arrangement of apparatus as employed in connection with the Lummus absorption system of solvent recovery from fixed gases (patent pending). Briefly, the method consists in scrubbing a residual gas-vapor mixture by means of a high-boiling condensate that has been previously removed from the initial gas-vapor mixture. The operation is described as follows:

The initial gas-vapor mixture, whether it be coke-oven gas, illuminating gas or the products of cracked petroleum, is led into a condenser, shown at the top of Fig. 1, in which partial condensation is effected, limited principally to the higher boiling constituents. This condensate is cooled in the cooler, shown directly below the primary condenser, and then admitted to the top of the absorber or scrubber, shown at right. The residual gas-vapor mixture, issuing from the primary condenser, is thoroughly cooled in the large cooler shown at left, from which it passes into the base of the scrubber, within which it is caused to bubble repeatedly and in counter-current fashion through seals flooded from above with the cold high-boiling condensate, as previously described. It is at once obvious that the scrubbing or absorbing operation is in all essential respects the same as that commonly employed in all absorbing operations. We strongly recommend a type of absorber that insures positive counter-current contact between gas and absorbent, instead of the "hurdle" type of absorber, which permits of surface action only, thereby requiring an excessive amount of absorbent and an absurdly large superficial area. However, this important distinction will be discussed later in greater detail, the main point to be emphasized here being the novel feature of the system described, whch consists in the use of the higher-boiling constituents of the initial gas-vapor mixture as the ideal absorbing medium. It directly follows that the use of this available absorbing medium removes the need of an external petroleum or tar-oil absorbent, and incidentally eliminates the many troublesome and inherent difficulties common to the repeated use of such absorbents.

Tar as Ideal Absorbing Medium

It will be immediately realized that the gas-vapor-tar combination, common to all methods of illuminating-gas manufacture as well as to by-product coke-ovens and petroleum-cracking processes, directly lends itself to the same method of gas treatment described above. In the case of the gas works, the partly purified gas from which toluol is to be recovered has already been largely relieved of its burden of tar, the latter constituting the high-boiling portion of the initial gas-vapor mixture. This tar is none the less available as the ideal scrubbing medium for the residual, toluol-bearing, gas-vapor mixture, and it may be so used with many obvious advantages if certain simple conditions be complied with. Furthermore, the use of tar as the scrubbing medium has long since been removed from the

realm of mere theory and experimentation. The so-called Carpenter process, as successfully employed throughout Great Britain, according to best obtainable information, refers to the identical procedure that we here recommend and which, as stated, we have been using successfully in connection with the products of cracked petroleum and originally conceived by us in the summer of 1913. We therefore feel that we are not offering an untried process, and trust that the many advantages of this method of procedure will at least claim the attention and careful investigation of our Government officials who have in hand this important problem of intensive toluol production.

Accompanying Fig. 2 illustrates diagrammatically our proposed absorbing and stripping system, using tar originally contained in the gas as the ideal absorbing medium to remove toluol from the residual gas mixture.

The various steps involved in the operation consist in warming and dehydrating the tar, cooling the tar to 60 deg. Fahr. or lower, and then causing positive counter-current contact between the cold tar and the cold gas in a suitable absorber. The "benzolized" tar issuing from the absorber is finally treated in a continuous stripping still, in order to remove the total light-oil fraction comprising the portion recovered from the gas and also that originally present in the tar as well.

Condensers and heat interchangers are employed, as indicated, to improve economy in respect to heat consumption. The residual tar, free of its light-oil content, emerges from the process and is available for use as road binder or for other purposes as special conditions may determine.

Distinctive Features of the Lummus System

The following distinctive features of the above process should be especially noted: In the first place, tar which is already available at all plants constitutes the scrubbing medium, and thus obviates the necessity of employing a foreign absorbing oil. In the second place, the tar absorbent makes but one passage through the system. The repeated use of the absorbing medium, common to other processes recently suggested, is thus avoided, as well as the constant re-standardization of the absorbing medium and repeated treatments for removal of naphthalene, which in the case of the cyclic system otherwise soon renders the oil unfit for absorbing purposes.

Centrifugal Tar Dehydration

Careful dehydration of the tar is essential to insure high absorptive efficiency. In our opinion the dehydrating operation can be performed most economically by means of the centrifuge. It appears that even water-gas tar may be dehydrated in this manner if heated to approximately 80 deg. C. in order to obtain a favorable difference in gravity between the water and tar. Lunge describes this method of tar dehydration and mentions an observed cost in the neighborhood of 25 cents per ton. We have confirmed Lunge's assuring statements in respect to centrifugal dehydration and incidental cost of operation by discussions with American centrifuge manufacturers, and find that at least three reputable American concerns are familiar with the problem and are ready to build the special form of centrifuge required. One concern was prepared to state the cost of centrifugal dehydration of coal tar, calculated from test runs, at 44 cents per ton, based on a tar emulsion containing as high as 50 per cent of water. We had previously corrected Lunge's figure to 50 cents a ton, allowing for present abnormal cost of power and labor. In this connection it is interesting to note that two of the concerns referred to have experimental departments, suggesting the desirable possibility of submitting to them samples of tar as produced by

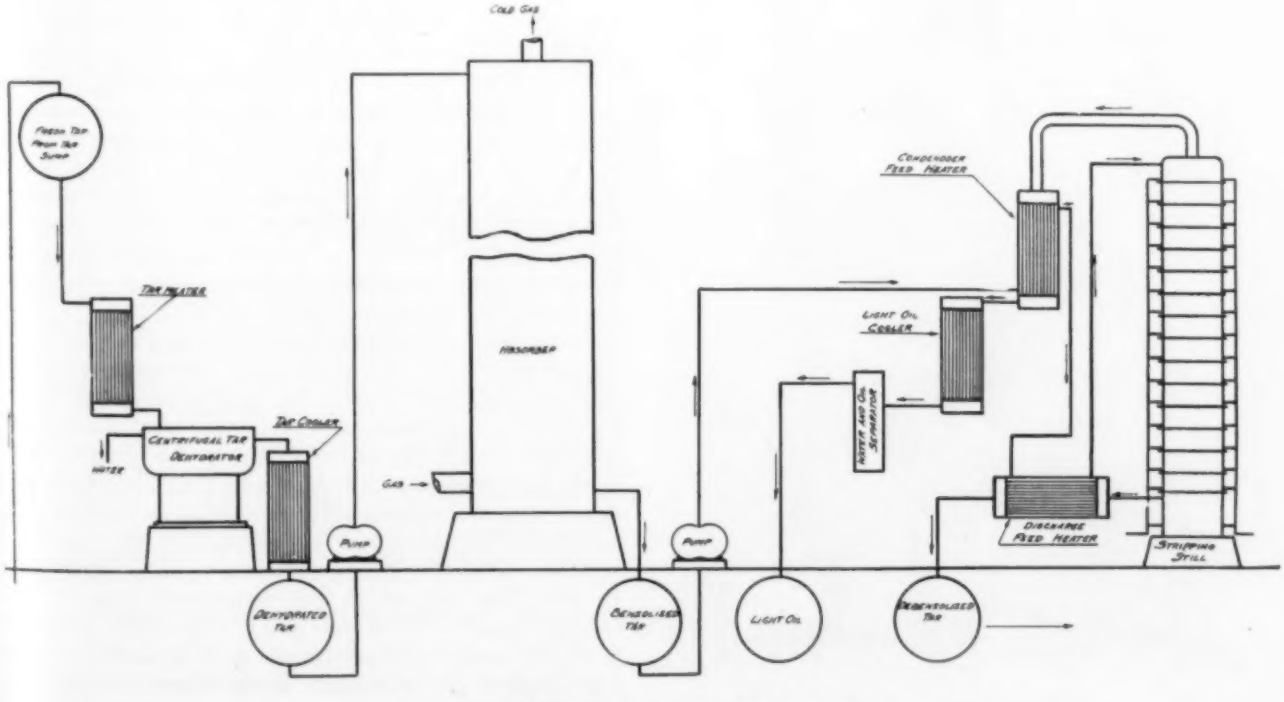


FIG. 2. ABSORBING AND STRIPPING SYSTEM

different gas works, in order that the best conditions for centrifugal dehydration could be determined for each particular case.

The "Cap-and-Seal" Absorber

In respect to absorbing apparatus, we strongly recommend the so-called "bubble" or "cap-and-seal" type. Accompanying Fig. 3 illustrates one arrangement of this type of absorber successfully employed by us for years past in connection with various solvent-recovery undertakings. The main arguments in favor of this type, as opposed to the "hurdle" type of absorber, are:

(1) The definite relation made possible between the quantity of absorbing medium used and the volume of gas to be scrubbed.

(2) The positive and repeated contacts assured between gas and absorbing medium.

This is to say, the "cap-and-seal" arrangement permits of admitting the exact amount of absorbing medium required to remove satisfactorily the volatile constituents of the gas in a single passage through the apparatus, which, together with the intimate contact caused between gas and absorbing medium, insures the utmost economy of operation. In the case of the "hurdle" tower, absorption is entirely dependent on surface contact, the ineffectiveness of which is clearly demonstrated by the tremendous amount of surface made necessary, requiring towers 60 to 75 feet in height, and in most cases using two such towers connected in series. Furthermore, the "hurdle" tower requires thorough wetting of all the surfaces, which can be accomplished only by extravagant use of absorbing oil, out of all proportion to the amount required for actual absorption. This means not only a large and useless investment in absorbing oil, when employing a foreign oil, but the cost of pumping this excessive amount of oil repeatedly to the extreme heights mentioned is an item of expense that does not seem to be entirely justified.

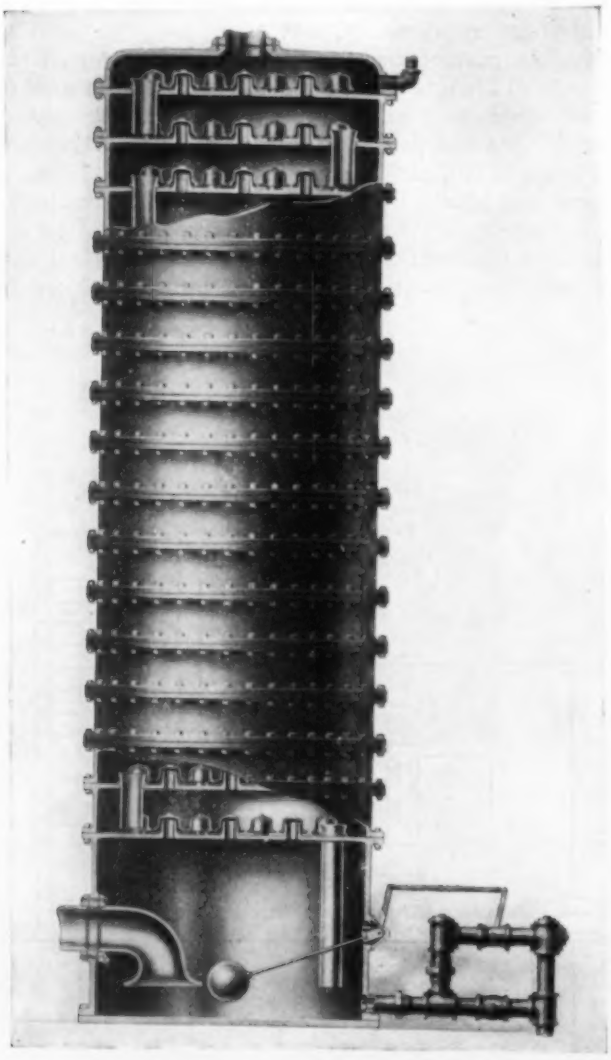


FIG. 3. CAP-AND-SEAL ABSORBER

Following is a striking illustration of the very satisfactory results obtainable with "bell-and-seal" absorbers as compared to towers filled with packing material for surface absorption such as the "hurdle" type. A prominent American concern recently desired to recover alcohol, acetone, etc., from the air-vapor mixture of these solvents, formerly wasted from an important drying operation. They first tried tall towers 25 or 30 feet in height and 4 feet in diameter, filled with packing material for surface absorption, using cold water as the absorbing medium. The results obtained were discouraging poor, indicating the need of much higher towers and an excessive amount of water to thoroughly wet the surfaces. We advocated a "bell-and-seal" absorber as being cheaper and far more efficient, and later installed a seven-tray absorber of the "bell-and-seal" type, measuring 24 in. square and standing about 5 feet high, equipped with Lummus patent atomizing caps. This small absorber effected practically complete recovery from the same volume of air and under the same conditions that previously applied to the rejected surface absorber. Water was used as the absorbing medium in the case referred to. It stands to reason, however, that exactly the same conditions apply, whatever the gas-vapor mixture or absorbing medium may be. Just as crude distilling colums, depending only on surface contact, have been largely abandoned in favor of "cap-and-seal" columns, so we believe will "hurdle" towers be abandoned eventually, for the more efficient and compact absorbers, and for quite similar and fundamental reasons.

Though we have no definite information as to close costs of "hurdle" towers, we are rather confident that their equivalent in the shape of "bell-and-seal" towers, in view of the limited number of trays or decks required, are no more expensive, at the same time offering the advantages cited, namely, while positive contact and minimum quantity of absorbing oil, with consequent economy in respect to the amount of absorbent required and the reduced cost of pumping.

Returning to our process, involving the use of tar as the scrubbing medium, it becomes very essential to use some efficient form of absorber, such as suggested above, for the obvious reason that an unlimited amount of tar per plant is not available. However, the quantity naturally produced has been shown by Dr. Carpenter, and demonstrated by English practice, to be sufficient for scrubbing the accompanying quantity of gas. Its use entirely eliminates the otherwise necessary investment in absorbing oil, which we understand costs in the neighborhood of 10 cents a gallon. Even the conservaly stated wash-oil requirement of 10 gallons per 1000 cubic feet of gas represents a considerable investment, especially when it is remembered that a large surplus

is required and frequent replacements are necessary to balance unavoidable losses.

We have designed a very simple form of absorber, which retains all the advantageous features of the "bell-and-seal" type, but excludes the rather expensive construction that usually applies to this type of tower. Our aim in this connection has been to develop an improved form of absorber, lending itself to economical construction throughout, so that even large sizes can be quickly made and without undue expense, at the same time entirely eliminating the intricate internal construction pertaining to hundreds of bells and seals required for the tower scrubber illustrated in Fig. 3. While we are not prepared to make positive claims in respect to this new type of scrubber, it appears, from estimates that we have been able to make, that it will be possible to reduce the cost of construction to less than one-half that applying to the usual "bell-and-seal" tower.

Advantages of Tar as the Absorbent

It may be well at this point to group some of the more obvious advantages applying to the use of tar as the absorbing medium:

a—The investment incidental to the use of a foreign absorbing oil is eliminated. This constitutes an important saving, especially when it is remembered that in the commonly described cyclic operation, a large excess of absorbing oil must be kept in readiness to take the place of the portion withdrawn from the process for special treatment to remove the naphthalene.

b—The appreciable and unavoidable loss of absorbing oil, requiring periodic replacement, is prevented by the use of tar absorbent in the non-cyclic system as suggested.

c—The toluol content of the original tar is recovered, as well as the portion obtained from the gas, and this is accomplished with one application of heat, without additional apparatus or operations.

d—The accumulation of naphthalene and other objectionable heavy oils in the tar becomes of no consequence, because the tar is used but once. This removes the necessity of elaborate chemical control and periodic external treatment of the absorbent for removal of the naphthalene, etc.

e—Should it now or later be required to recover the carbolic oil present in the tar, this may be accomplished simultaneously with the stripping of the light oil. Other methods of procedure exclude the tar and therefore would require additional equipment and use of heat should the tar constituents become of great importance.

f—As large and small gas plants produce tar in proportion to their gas output, the process becomes applicable to plants of whatever size, and similar types of apparatus would apply to recovery from water-gas, as well as from coal-gas and all other sources.

g—The entire elimination of an external absorbing oil removes the serious situation that would result in the event of a shortage of "straw" or tar oils required for unlimited development of the cyclic "absorbing and stripping" process.

h—The light oil produced by the proposed process would not contain absorbing oil requiring separation and return to the cycle. Therefore this light oil could be shipped to a central refinery without involving loss of absorbing oil.

i—No shut-downs would occur, due to delayed shipments of absorbing oils. Elimination of any important dependence on overtaxed transportation facilities, except for out-going concentrates, is thus assured.

Lummus-Hirzel Stripping Still

Accompanying Fig. 4 illustrates the Lummus adaptation of the so-called Hirzel stripping still, employing high-pressure steam in closed coils for maintaining a required temperature within the still, and with superheated steam injected into the lower chamber of the apparatus to assist evaporation of the light oil by repeated contacts through the large bell seals, as shown. It hardly needs to be explained that the so-called "benzolized" tar is admitted to the top chamber of the still and is caused to flow downward from chamber to chamber, counter-current to the upward passage of steam and vapor bubbling through the bell seals. The vaporized light oil, together with steam, passes over to a condenser, in which the mixture is condensed and cooled, and the light oil subsequently separated by means of a gravity separator. The "de-benzolized" tar, as pre-

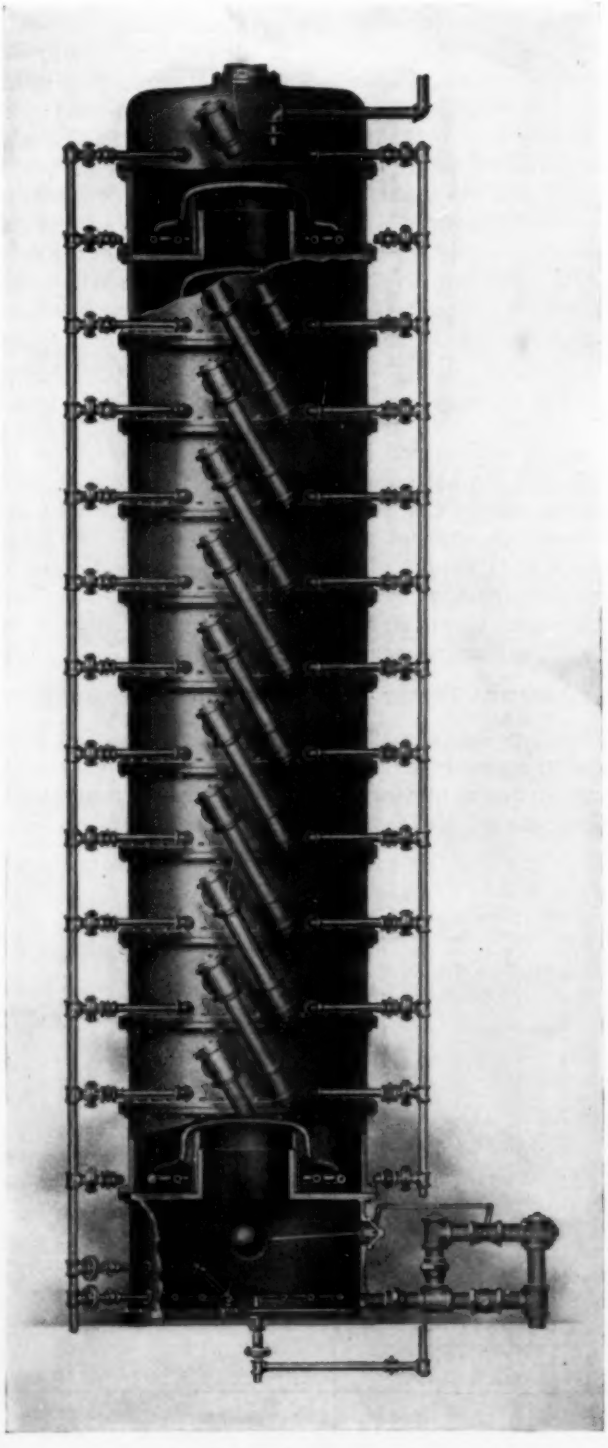


FIG. 4.—STRIPPING STILL

viously explained, issues from the lowest chamber of the still, and, after giving up its heat to the incoming "benzolized" tar, through a suitable heat interchanger, has completed its usefulness and is ready for sale or other disposal, as particular circumstances may determine.

Hirzel has quite properly pointed out that the above is not essentially a distilling operation, but rather one of separating a comparatively volatile body from one of low volatility by means of evaporation. On this account, a relatively constant temperature is maintained throughout the series of chambers, this being contrary to conditions favorable to true distillation, in which case the temperature decreases from the bottom toward the top of the column, corresponding to the rate of increasing the percentage of the low-boiling component in the ascending vapors. The Hirzel apparatus, therefore, is merely a convenient form of evaporator, for exposing the "benzolized" tar to heated surfaces simultaneously with repeated contacts with superheated steam and its associated light-oil vapor. Instead of placing pressure steam-coils within the respective chambers of the still, the tar may be superheated prior to its admission to the top chamber of the still. This procedure undoubtedly permits of simplifying construction somewhat, but has the disadvantage of being wasteful of steam. Under the most favorable conditions there is sure to be loss of superheat before the tar enters the column, and the temperature within the column must be maintained by an excessive use of steam injected at the bottom chamber. It is far more economical to supply the required superheat within and distributed throughout the column exactly at the points where it is needed. Furthermore, we have devised an improved design of the Hirzel type of still, simplified in respect to construction without losing any of the desirable features mentioned.

Lummus Direct-Fired Stripping Evaporator

During the year 1913 we carried on experiments on a semi-commercial scale to ascertain the behavior of certain gas tars when subjected to continuous superheated-steam distillation for the removal of the light-oil fraction. The apparatus comprised a modification of the Hirzel internally steam-heated still, and test runs were made, using both coal and water-gas tars. The results obtained conclusively proved the practicability of handling tars in this manner as opposed to the usual American practice of using direct-fired batch stills. It was found possible to completely remove the light and heavy oils, leaving a hard residual pitch; and the troublesome boiling-over habit, common to all batch tar stills, was entirely eliminated. But unfortunately one great disadvantage presented itself in too prominent a manner to be overlooked. The consumption of steam, both as superheated steam and pressure steam within the coils, was so great as to affect seriously the possibility of an extensive application of this otherwise very satisfactory procedure. We call attention to our experience in this connection, as conditions applying to all steam stripping processes appear to be identical to those encountered by us in respect to continuous distillation of tar with steam. Under the most favorable conditions, employing all possible heat economizers, we still found that the excessive consumption of steam constituted an item of expense that will at least bear thoughtful investigation.

In view of the above, we have been led to devise a new type of stripping still, which includes all the advantages of continuous operation without requiring the use of an excessive amount of steam. Furthermore, the design finally arrived at is very simple as compared to the Hirzel still and promises to be comparatively inexpensive. Accompanying Fig. 5 illustrates in a general way the arrangement of apparatus suggested. The "benzolized" tar, admitted at *A*, is made to flow in a very shallow stream throughout the length of the horizontal direct-fire-heated evaporator, as shown. Vertical diaphragms, with openings at alternate sides, are used to prolong the path of the tar over the heated surface. The "de-benzolized" tar issues at *B*, the sensible heat of which is utilized in warming the "benzolized" tar prior to its entrance into the evaporator at *A*. The residual tar, free of light oil, has thus, as before stated, served its entire useful purpose, so far as the recovery of toluol is concerned. Note that the "benzolized" tar enters at

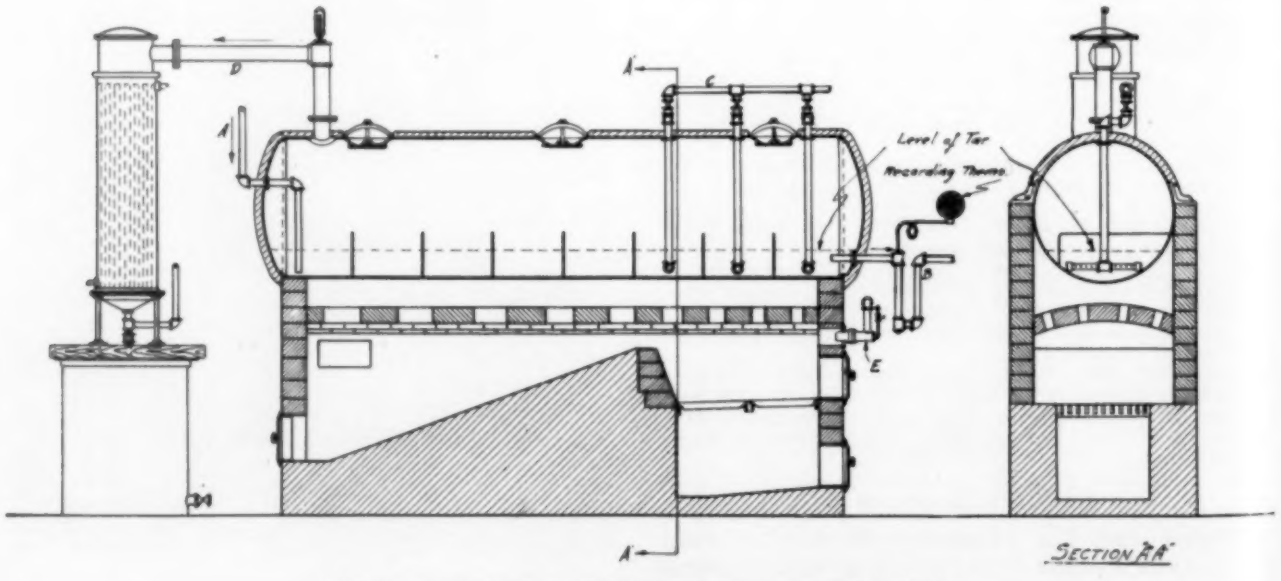


FIG. 5. DIRECT-FIRED CONTINUOUS STRIPPING EVAPORATOR

the cool end of the evaporator and the "de-benzolized" tar leaves at the hot end, with consequent countercurrent advantages. Pipes marked *C* indicate means for injecting live superheated steam in the last three compartments, as possibly required in the event of desiring to remove the heavy as well as the light oils from the tar. The light-oil vapors pass through *D* to the condenser, to be condensed and cooled, ready for subsequent toluol concentration and refining. The evaporator may be heated by means of a coke fire used in conjunction with a tar burner, to permit reasonable regulation of temperature to avoid coking the tar. Should it appear desirable in some cases to operate at favorable low temperatures, a vacuum may be maintained within the evaporator by means of a vacuum pump attached to the outlet of the condenser. The small amount of steam required to operate the vacuum pump would not be of serious consequence. However, even this slight complication would not be required except perhaps in the event of carrying the evaporation to the point of producing a hard pitch.

Accompanying Fig. 6 illustrates the Lummus system of absorbing and stripping, the same in principle as indicated by Fig. 2, but substituting our direct-fired striping evaporator for the Hirzel type of steam-heated stripping still. In this case we do not attempt to utilize the heat of condensing the light-oil fraction, as the incidental saving does not seem to warrant the necessary apparatus complications. This apparent disregard of economy seems justifiable, due to the low cost of direct firing and the excess furnace heat available in spite of the most careful regulation of firing. On the other hand, the high pitch sensible heat of the residual tar is used for heating the incoming "benzolized" tar, as shown.

The apparent advantages of this direct-fired stripping evaporator may be enumerated as follows:

(a) The simple brick settings and inexpensive plate construction would seem to indicate a very low cost for this equipment as composed to that of the steam stripping stills.

(b) The total elimination of steam-heating and evaporating insures a marked reduction in operating expense, especially as coke and tar could be used as fuel.

(c) The convenient and easily understood operation is best adapted to labor conditions now obtaining at most gas works.

(d) Many boiler shops could turn out the evaporator shells quickly and in quantities. The Hirzel stills, involving castings and machine work, would prove a source of much more serious delay.

It must be admitted, in fact it is an assuring feature, that direct-fired continuous tar evaporators have been successfully employed in Europe. We are informed that their operation is simple and convenient, and results in respect to light-oil recovery are satisfactory. So again we merely suggest an improved form of apparatus that is not entirely new and untried in the sense of involving risk of unforeseen difficulties. Furthermore, we would not recommend the use of this still for "benzolized" straw-oil resulting from the cyclic process. The tendency to evaporate the lower-boiling portion of the absorbent would be, in our opinion, a serious objection, which, however, does not in any sense apply in the case of "benzolized" tar, which makes but one passage through the system.

Summary of Recommendations

Briefly summarizing the above article, we offer the following recommendations in the hope of stimulating, to whatever extent may be within our power and ability, an intensive toluol production:

a—The immediate organization of a Government-controlled and directed machine to develop a sufficient toluol supply with the same spirit and effect with which it is developing an army.

b—The prompt utilization of all available toluol sources and the simultaneous development of new sources to meet an ultimate requirement far beyond to-day's popular though erroneous conception.

c—More simple and efficient recovery methods and equipment, to conserve our limited resources against the possibility of a long and exhausting struggle.

d—Specific recommendations in respect to the "absorbing and stripping" process, including the use of tar as the ideal absorbent and more economical types of absorbers and stripping stills.

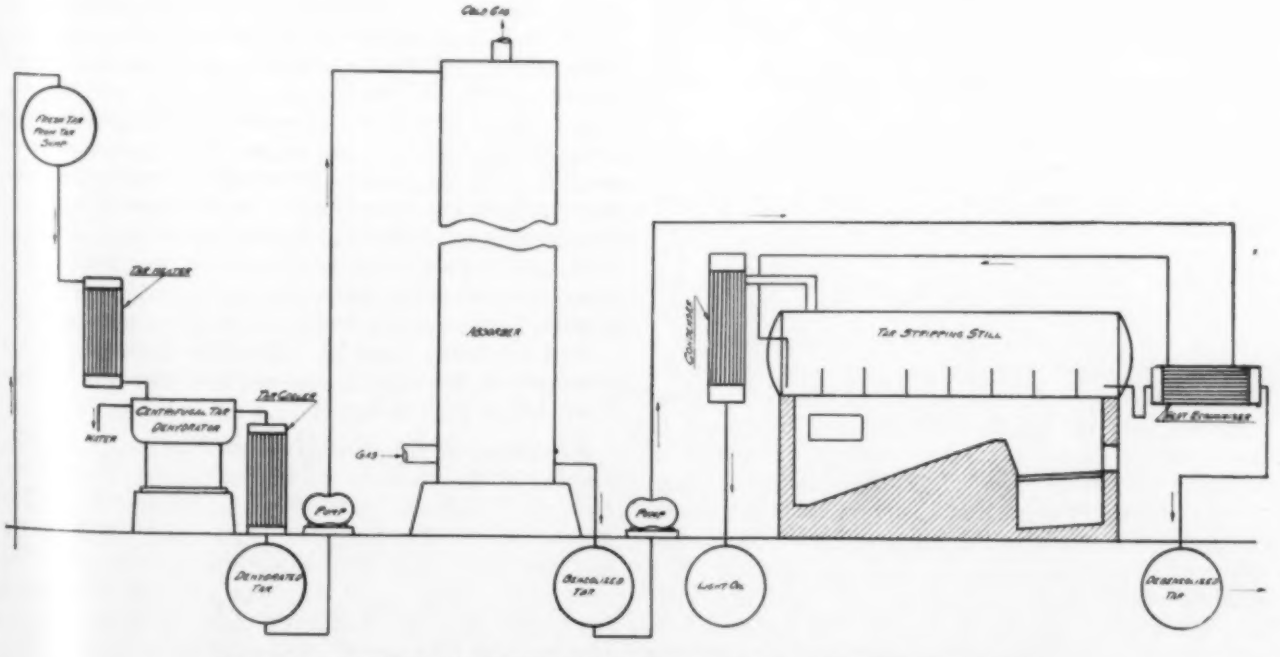


FIG. 6.—ABSORBING AND STRIPPING SYSTEM WITH DIRECT-FIRED EVAPORATOR

e—A thorough investigation of the real effect of the presence of paraffins on the manufacture of munitions, together with an educational campaign that may be required to overcome unfounded prejudice against paraffins.

f—Economical methods of munitions manufacture, especially to avoid waste of toluol, that the limited supply may be conserved to the utmost.

g—Finally, that there may be a country-wide awakening to the fact that our present insufficient toluol supply, unless quickly and effectively remedied, means defeat. This certainly is sufficient cause for grave concern, demanding utmost foresight and concerted, energetic action.

In conclusion, may we state that our recommendations, though intended to be highly practical and conservative, do not anticipate a hurried acceptance without careful preliminary investigation. The most we ask is a thorough consideration of our various suggestions, to be followed, if it appears warranted, by minor plant installations to definitely determine the degree of utility and dependableness of methods and equipment outlined. We also hope that sufficient publicity of our broader general plans may be realized for whatever good may result from our attempt to analyze existing conditions and to assist in stimulating a greater appreciation of the stupendous task that confronts us as a Nation.

It can hardly be said that we have taken ourselves too seriously. The occasion surely demands plain-spoken views and a pooling of experience and efforts, by which alone can we attain success. We recognize a duty in making known thus definitely such services as in our opinion we are best prepared to render.

The Walter E. Lummus Co.
Boston, Mass.

Synopsis of Recent Metallurgical and Chemical Literature

Temperature of Liquid Steel.—At the November meeting of the Faraday Society, in London, Mr. COSMO JOHNS spoke on "The Determination of the Temperature of Liquid Steel Under Industrial Conditions." Pointing out that skilled observers, with the aid of blue glass, were able to distinguish differences of 15 deg. C. when steel was flowing into a ladle, and that observers watching the same steel running into the ingot mold could distinguish temperature differences of about 10 deg. apparent, it was clear that any system of pyrometry to justify adoption must be able to record apparent temperatures with 5 deg. ± as the permissible variations. The system adopted, after much preliminary work, was the use of optical pyrometers using monochromatic light, and these had now been used in regular works practice for nearly four years. It was concluded as a result of this experience that concordant results of the required degree of accuracy required carefully trained observers, and the adoption of standard conditions of observation. Casual observers without knowledge of the many sources of error might easily obtain readings which departed 50 deg. from a correct reading. Observations must be made on the windward side of a launder down which steel was flowing from the furnace. If a value for the average temperature of that particular cast of steel was required, in order to determine its variation from the "normal" adopted for that particular practice, an observation of the center of the exposed side of the stream as it falls over the open end of the launder into the ladle when half the contents of the furnace had run out gave the best results. Such streams gave small but consistently different readings at the top, middle and bottom of the exposed side. The stream as it issues from the furnace taphole rises regularly in temperature as the successively hotter layers run out. The slag follows the same rule, but though serial readings obtained near the taphole have given much information as to the temperature gradient within the bath in the open-hearth furnace, it has not been found possible so far to explore the extreme ends of the gradient. That it is extremely steep near the surface of the bath is very probable, from the fact that it is in contact with the intensely hot flame of the furnace, and from the fact that under very favorable conditions the purest quartz sand has been fused, when floated on the surface of the bath, to a viscous fluid. Only "clean" surfaces of steel, free from oxide films, are suitable for observation, and these must of necessity be either rising in temperature, if flowing from the furnace, or falling in temperature if it is flowing from the casting ladle. Any temperature determination of liquid steel in open-hearth practice possesses no significance unless the relative time at which the observation was made is recorded. Owing to the importance of determining the softening or fusion range of the refractories, observations were made on the temperature of the interior of the furnace walls. As it was impossible to secure "black body" conditions, care was taken that the surfaces observed were "free radiators." These observations were therefore made after the furnace had been tapped. The gas was shut off and the door through which the pyrometer was sighted was lifted until wide open. Under these conditions every detail inside the furnace was visible: the joints in the brickwork, the junction of the sand banks with the side walls, port openings and places where wear had occurred, could all be perceived. Patches of new bricks could easily be distinguished from the adjoining old brickwork owing to their higher emissivity, though obviously at the same real temperature. It was suggested that if the emissivity of new silica bricks could be experimentally determined at 1650 deg. C. a very useful datum point would be available from which the emissivities of the surface of the slag and the seasoned bricks could be calculated. The emissivities adopted are tentative, and merely represent what best accords with the facts. Pyrometer readings of steel flowing from the ladle into an intermediate trough into the molds are tabulated, and the effect of oxide films with their higher emissivity is clearly indicated. It is concluded that under exceptionally favorable conditions a trained observer can repeat his readings with a variation of 2.5 deg. ± apparent while the variations in the observations discussed in the communication are something better than 5 deg. ±.

Hardening of High-Speed Steels.—At the November meeting of the Faraday Society in London, Prof. J. O. ARNOLD (University of Sheffield) spoke on "Pyrometry Applied to the Hardening of High-Speed Steels." He said the advantage of pyrometrically controlling the hardening of high-speed steel was a matter of common knowledge, and the most usual and best average temperature was 1300 deg. C. The practice at Sheffield University was to immerse the tool to be hardened in a

bath of fused barium chloride melted by a current which passed through two iron electrodes. This secured perfect regularity of temperature. The tools were then quenched in air, oil, or water.

Experiments were described in which five different pyrometers were used simultaneously; the Féry thermoelectric radiation pyrometer, the Féry bi-metallic spiral spring pyrometer, the Foster base-metal thermocouple, a modified Wanner radiation pyrometer, and the Mésure and Nouel, which Dr. Arnold favored very much, but in which the personal element was important. Using these different instruments and employing different observers, a grand mean temperature of 1296 deg. C. was arrived at, which was a tribute to the accuracy and reliability of the various methods of getting good observations. Dr. Arnold concluded by describing some observations that he had made on the casting temperature of steel tapped from an open-hearth furnace. The evidence of the results showed that such observations could be made reliable.

Potash from Feldspar.—In the Bulletin of the Institution of Mining and Metallurgy, Dec. 13, 1917, E. A. ASHCROFT describes experiments on the producduction of potash from feldspar by an interesting method. He has worked out an industrial process and gives cost figures. In the process, orthoclase or microcline feldspar is dry crushed to 100 mesh (I.M.M.) in an iron mill and mixed with its own weight of pure dry common salt and then heated to 900-1000 deg. C. for two hours out of contact with air or moisture, or furnace gases carrying such air or moisture.

The sodium base of the salt displaces the potassium base of the feldspar strictly according to the equation:

$$2NaCl + K_2OAl_2O_3(SiO_2)_6 = Na_2OAl_2O_3(SiO_2)_6 + 2KCl.$$

If the temperature has not exceeded 1000 deg. C., and if moisture and air have been carefully excluded, the author states that the product will be found to consist of finely divided insoluble sodium feldspar (albite) and a mixture of quite neutral and freely soluble sodium and potassium chlorides. These chlorides may be readily lixiviated in water and are easily separated from each other by fractional crystallization.

The extraction of potash obtainable by this means from a sample of feldspar carrying upwards of 10 per cent K_2O will be in the neighborhood of 85 per cent under the conditions above stated. There is no loss by volatilization, and the weights of residue and salt will be found to correspond with the equation.

The experiment can be carried out in a large porcelain crucible (covered), or equally well in a sealed iron or nickel receptacle. Metals are not attacked so long as air and moisture are absent. These containers may be heated in an ordinary assay muffle for the experiment. If metal containers are used, it will be found that only on the outside of the vessel is there any attack, and this is due to air in the muffle. If air and moisture are excluded from the muffle, and a reducing or inert gas substituted, the containers will be very durable.

The author has independently discovered and studied this reaction, but he gives credit of priority for the discovery of the displacement of potash by soda obtained from salt to E. Bassett, who in 1913 patented in the United States and Canada a process based on the same reaction. The author has found that Bassett overlooked the necessity of excluding air and moisture. The author recommends the following as an emergency outfit: A standard bench of large "D"-shaped gas retorts (having 8 retorts to the panel and 10 panels, each panel having its own producer), and all the retorts inverted and provided with new metal end pieces of simple design. The whole furnace outfit is complete for no less than 50 tons potassium muriate of 80 per cent quality per day. That is as much potash as can be recovered from all the 300 blast furnaces in England put together, and assuming all that source of potash to be made available by means of expensive equipments of fume collectors and precipitators.

The author estimates that in normal times the 80 per cent salt will not cost 7*l.* per ton and not more than 15*l.* to 20*l.* even under war conditions. He says that any potash process with feldspar as raw material, if it is to be successful on an extensive scale, must stand or fall by a single product.

The whole problem then changes its aspect from a hopelessly complicated to a very simple economic problem, easily comparable with any simple mining venture.

The desirata for such an undertaking may be stated thus:

(1) Raw material in extensive deposits which can be quarried cheaply.

(2) Reasonably high and uniform potash content of feldspar.

(3) Water-borne freights for supplies to and from quarries.

(4) A simple and cheap process with reduction works on the quarry sites and not consuming acids or any other expensive materials.

All these desiderata are realized in the extensive deposits in Sutherlandshire, and, no doubt, they can be realized quite as favorably in many other parts of the world, in selected localities, if the same simple aims are kept in view, and the principles and process described are applied.

In New Zealand, in Australia, in Canada, and in parts of the United States, in Portugal, in Italy, and in other places there are favorable deposits of pegmatite feldspars, which lead me to anticipate that this source of potash supply may yet fill a large part of the world's requirements.

All consideration of by-products in such schemes should be a secondary thought, and should not form an essential part of the scheme. The author does not doubt that in some cases the treated feldspar may find useful applications and so add to the returns, but it must not be depended on for the results of any such enterprises.

When Are Chemical Results Patentable.—An interesting discussion of a decision handed down by Judge R. E. Lewis in the Eighth Circuit Court of Appeals in Chicago was given in the Chicago Chemical Bulletin for December. The suit was between the Corona Chemical Company and the Latimer Chemical Company. The discussion was as follows:

"The judge has made the ruling that the every-day

knowledge of the chemist which may prompt the execution of a successful experiment is not inventive genius. That the raising of the efficiency in degree only of any process without the accomplishment of any new function (if this efficiency is brought about by common knowledge of the chemist, his shop practice), this improvement is not patentable. This raises for the chemist the whole problem of what constituted new and useful improvement in the art of chemistry. In other words, what is a patentable invention in chemistry? This matter is of very great importance at the present time, because it is obvious that the whole subject is not clearly defined for the courts of America, and it is surely in the interest of chemists generally to define invention or discovery of a patentable nature in the chemical art rather than to require this definition at the hands of our American judiciary. Why not define it now rather than leave the matter in the hands of the lawyers and judges of our country and have forced upon us definitions, ruling limitations which may be troublesome or even disastrous to our fraternity?

Recent Metallurgical and Chemical Patents

Production of Oxalic Acid.—A process for the production of oxalic acid is patented by C. T. THORSSELL and H. L. R. LUNDEN, of Gottenborg, Sweden. The process relates to the production of oxalic acid from sodium oxalate, which is mixed with sodium carbonate and a little caustic soda.

"Oxalic acid and sulphate of sodium are obtained from the oxalate of sodium when sulphuric acid is added to the mixture of the three first-mentioned salts, and the sodium carbonate and the caustic soda are also transformed into sulphate of sodium. But this cannot be carried out conveniently in one operation, as acid oxalate of sodium precipitates and to get this transformed into oxalic acid so great a surplus of sulphuric acid would be needed that all the sodium would be present in the form of acid sulphate and there would still be a surplus of free sulphuric acid.

"By dividing the reaction in two parts or stages of treatment it can, however, be carried out with the desired result. Thus in the first stage the oxalate of sodium is transformed into acid oxalate of sodium and neutral sodium sulphate, and the sodium carbonate and the caustic soda are also converted into neutral sodium sulphate by means of a solution containing acid sulphate of sodium and sulphuric acid, which solution may be conveniently obtained from the second stage of treatment, thus making the process a continuous one.

"In the second stage the obtained acid oxalate of sodium is treated with sulphuric acid, whereupon oxalic acid and a solution of acid sulphate of sodium are obtained together with sulphuric acid, which may be used in the first stage of the repeated operation for the solution of the oxalate. Thus, in the first stage a solution obtainable from a previous stage and a solid substance (from the oxalate furnaces) are used, and a solution (neutral sulphate, forming the finished article) and a solid substance for subsequent use in the second stage are obtained. At the second stage a liquid (sulphuric acid) and a solid substance from the first stage are used, and a solution for subsequent use in the first stage, and a solid substance (oxalic acid=end product) are obtained.

"The finished oxalic acid must be washed with water and recrystallized so that it becomes perfectly pure, and besides it is advantageous to wash the acid oxalate a little, before it goes to the second stage. These washing liquids may be utilized without evaporation. The sulphate of sodium as well as the oxalic acid crystallize with water, and therefore a great quantity of water must be utilized in the operation. It is true that a little water is brought in with the sulphuric acid and that smaller quantities are formed when the carbonate of sodium and the caustic soda are converted into sulphate, but still the greater part must be added in the form of washing liquids. The method of working is thus made a little more complicated. (1,251,938, Jan. 1, 1918.)

Extraction of Rosin and Turpentine.—Improvements in the extraction of rosin, turpentine and oils from resinous wood are patented by JOHN E. TEEPLE, of Montclair, N. J. They comprise a process of extraction from resinous wood such as lightwood, stumps, pine slabs, etc., wherein such wood is heated and treated for a time in simultaneous contact with water and with spirits of turpentine, both the water and the spirits of turpentine being at their joint boiling point (the boiling point of the mixture) and such heating being conducted without substantial escape of vapors and the contact being either with condensing liquids or with a mass of each liquid. The extracted matters are removed together with water and solvent; and the wood is steamed to recover adhering solvent. (1,252,058, Jan. 1, 1918.)

By-products from Mine Water.—WM. M. PARKIN of Pittsburgh, Pa., patents a process of treating mine water containing sulphuric acid and iron salts. Water issuing from mines and particularly coal mines is a weak but highly corrosive solution containing acid, and is detrimental to fish life as well as destructive to submerged metal work, such for example as tanks, pipes, etc. These mine waters generally contain considerable free sulphuric acid, together with more or less aluminium salts. According to the patent it is proposed to treat these mine waters with calcium carbonate, in amount sufficient to neutralize all the free acid and to react with most of the iron salts. A precipitate is formed containing basic iron sulphates which is separated from the remaining liquid and heated to a temperature between 179 and 338 deg. C. producing a finely divided pigment. (1,251,564, Jan. 1, 1918.)

Production of Sulphite Acid Liquor.—G. D. JENSSEN of New York City patents a system of producing sulphite acid liquor in which the function of the absorbing towers may be changed at will without affecting the efficiency of the operation, and in which the process is a continuous one. A diagram of the apparatus is shown in Fig. 1. The operation is described as follows:

"In operating the system with the tower 1 as a strong acid liquor tower, the traps 16, 20, 21 and 51 are closed, also the valves 24, 34, 37, 28 and 42, and the traps 12, 19, 22 and 50 are opened, also the valves 25, 33, 38, 43 29.

"The sulphuric dioxide gas flows into the pipe 13,

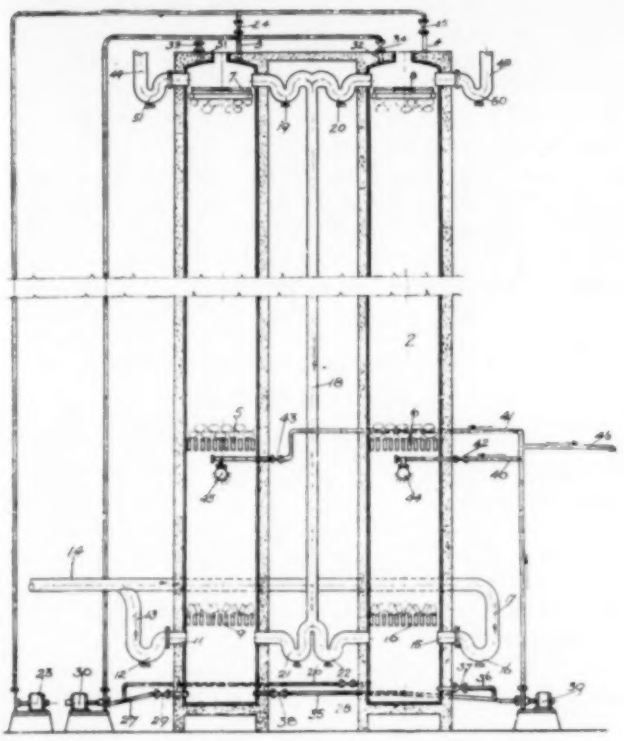


FIG. 1. DIAGRAM OF ACID SYSTEM

through the trap 12 and inlet pipe 11 to the tower 1 under the grate 9 and the tower 1 thus becomes part of the communicating passage from the gas plant for the initial and following flow of gas to the tower 2; which is the primary tower in the process of producing the acid liquor. The gas reaching the tower 1 rises in said tower through the blocks on the grate 9 and through the limestone pieces on the grate 5 and flows out of this tower through the trap 19 into the pipe 18 and down said pipe and through the trap 22 into the tower 2 under the grate 10 and rises in said tower 2 through the blocks on the grate 10 and limestone pieces on the grate 6 meeting the water being fed into the tower through the inlet pipe 4 as the said water trickles through the limestone and blocks. The spent gas exhausts through the trap 50 and pipe 48, being during the continuation of the process used in the two towers previous to its escape to the atmosphere.

"The weak acid liquor in the lower end of the primary tower is discharged through the pipe 26 to the acid liquor pump 30, from which it is forced up to the inlet pipe 31 and this weak acid liquor trickles down through the limestone pieces and blocks in the tower 1 and is met by the rising gas, which it largely absorbs, materially strengthening the acid liquor. The acid liquor flows out from the lower end of the tank 1 through the pipe 35 to the acid liquor pump 39, from which it is forced up to the pipes 41 and 46, a considerable quantity of the liquor flowing again into the tower 1 above the blocks and missing the limestone and thus apart from the latter absorbing the sulphur dioxide, so that the percentage of sulphur dioxide can be accurately gaged, this being regulated by the valve 43.

"To reverse the functions of the towers, 1 becomes the weak acid liquor tower and 2 the strong acid liquor tower, therefore the traps 16, 20, 21 and 51 are opened, also the valves 24, 34, 37, 28 and 42, and the traps 12, 19, 22 and 50 are closed, also the valves 25, 33, 38, 43, 29. Now the water is fed into the tower 1, and 2 becomes a communicating gas passage to tower 1 in the initial and following flow of gas thereto.

"The primary tower 1 receives its charge of gas from 2 which gas is absorbed by the trickling water and the weak acid liquor produced pumped into tower 2, from whence it flows to the acid pump 39 through the pipe 36 and from there it is pumped up to the pipes 40 and 46, the sulphur dioxide strength being regulated by the valve 42 as already explained.

"It will be seen that the process in certain parts follows out well known and practical knowledge in this art, but it also is a radical departure from common practice, as there is always an intervening tower between the sulphur dioxide plant and the primary tower and yet the towers may be reversed at will, thereby eliminating the necessity of shutting down the plant for washing the towers, as they are flushed regularly in use by the systematic change over of their functions. Then again each tower is provided with the means of regulating the percentage of sulphur dioxide, which may be used no matter how the towers are changed in regard to their functions and this is important both in the duplication of the parts and the novelty of the means employed. (1,251,533, Jan. 1, 1918).

Sulphur Dyes.—Two patents have been issued to Heinrich Heimann of Dessau, Germany, on sulphur dyes. The patents are assigned to the Actien Ges. für Anilin Fabrikation of Berlin. The first patent relates to the production of sulphur dyes by the action of sulphur on a mixture of an amino-, diameno-, nitrohydroxy-, and amino-azo compound with a C-alkylated diamine of the benzene and naphthalene series. One example of the process is given, as follows:

12 parts of meta-toluylenediamine, 20 parts of amino-azo-benzene and 80 parts of sulphur are heated together during about four hours upon say 180-230 deg. C. and then during about 1 to 2 hours to say 230-260 deg. C. The melt thus obtained is rendered soluble in the usual way by treating it with a concentrated solution of sodium sulphide. The new dye may be separated as usually for instance by introducing a current of air; it produces on unmordanted cotton in a dyebath containing an alkali metal sulphide beautiful olive shades which are fast to washing and to boiling diluted acids. (1,251,368, Dec. 25, 1917.) The second patent relates to the same class of dyes produced by the action of sulphur on a mixture of nitro-amino-azo compounds with a C-alkylated diamine of the aromatic series. An example follows:

16 parts of meta-toluylenediamine, 20 parts of para-nitrobenzene-azo-alpha-naphthylamine and 100 parts of sulphur are heated together to say 180-220 deg. C. during about 2-4 hours; the mass is then further heated during about 4-8 hours to say 220-260 deg. C. The melt may be treated as given above in order to obtain and purify the new dye which produces on unmordanted cotton a very beautiful yellow olive fast to washing and to diluted acid.

In a similar manner from a mixture of meta-toluylenediamine with para-nitrobenzene-azo-beta-naphthylamine a dye can be obtained which upon textile fiber produces a beautiful yellowish brown is likewise fast to washing and to boiling diluted acids. (1,251,368, Dec. 25, 1917.)

Baily Automatic Electric Furnace for Heat Treating Shells

The Electric Furnace Company of Alliance, Ohio, has developed an automatic furnace for heat treating high explosive and shrapnel shells. The furnace is an adaptation of equipments of similar size that have been used for some years in the heat treatment of steel railway and motor car parts. It combines the accurate temperature control of electric furnaces and the uniform quenching produced by the automatic manipulating device and eliminates almost entirely the manual handling of the shells. The makers state that the first cost is of course more than that of fuel-fired manually operated furnaces, but on contracts of any considerable size the labor saving and the elimination of rejections readily pay for the equipment.

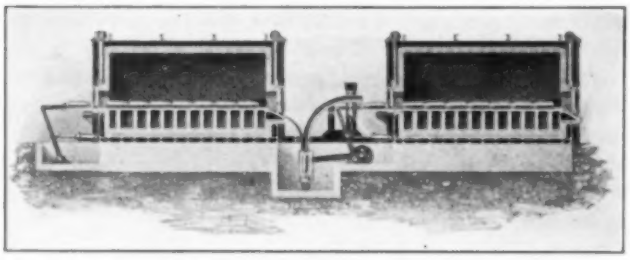


FIG. 1. CROSS SECTION OF TWO BAILY FURNACES WITH QUENCHING PIT

Fig. 1 shows a sectional view of two furnaces with a quenching mechanism located between them. The equipment includes a valve control pulpit and two contact-making pyrometers, one for each furnace. The couples of which are located in the discharge end of their respective furnaces, directly over the row of shells about to be discharged.

The operation of the equipment is as follows:

When the shells in the discharge end of the first furnace have reached the desired temperature, the heat from these shells actuates the pyrometer mechanism, closing a relay, and operating a solenoid on the radial dial switch of the pulpit, bringing the arm on the radial dial in contact with the switch, thus controlling the first movement of the equipment, which is the raising of the doors of the first furnace.

When the doors have been fully raised, the pusher on the first furnace pushes in the row of cold shells on the charging platform of that furnace, and, at the same time, pushes out of the discharge end the row of heated shells directly under the pyrometer tube. The pusher immediately reverses, and the doors close.

Meanwhile, the shells have dropped by gravity, nose down, on the quenching forks in the quenching pit, and immediately commence to rotate, the quenching water being turned on simultaneously and the shells sprayed from all directions, and internally.

At the same instant that the water is turned on, a time element, consisting of a disc operated by a constant speed motor through reduced gearing, is put in operation, and the water allowed to flow continuously for the predetermined time.

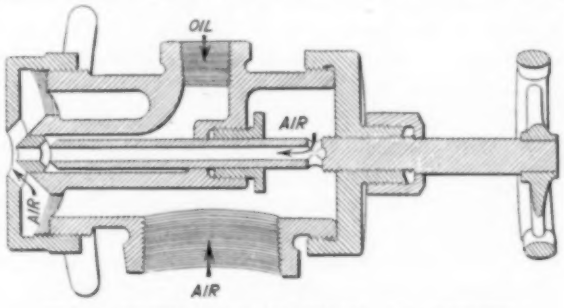
When the disk has made a complete circuit, the water is automatically shut off, the arms supporting the forks holding the shells move upward and deliver the shells in front of the pusher of the second furnace; the arms then return to their lower position ready to receive the next row of shells.

The quenched shells lie in front of the pusher of the second furnace until the shells in the discharge end of the second furnace actuate the pyrometer mechanism of that furnace, when a similar operation to the one described in connection with the first furnace takes place, pushing the quenching shells into the drawing furnace, and the drawn shells out at the discharge end. The only labor required is the placing of the shells on the charging platform of the first furnace, all other operations being performed automatically by the equipment itself.

A Fuel Oil Burner

In view of the difficulty of obtaining supplies of coal, attention is being turned in many quarters to other available fuels. In order to burn fuel oil it is necessary to have a burner, to atomize the oil and mix same with air. One type of fuel oil burner is shown in the accompanying illustration. It is known as the Coleman oil burner and is made by the Foundry Equipment Company of Cleveland, Ohio.

In this burner air is fed from the main air chamber through a hollow brass stem; the oil is fed around this circular stream of air, and at the end of the brass stem, which controls the oil supply, the oil is forced into the air stream at a sharp angle. This causes a breaking up of the oil into small particles and produces a primary mixing with the air. A second and larger



CROSS SECTION OF COLEMAN OIL BURNER

outer stream of air cutting through the primary mixture produces a further atomization and furnishes the proper combination of oil and air for complete combustion.

The burner was designed to overcome the clogging due to dirty and lumpy oil feeding through a small orifice. A quick means for clearing out any obstruction is provided by merely turning the hand wheel on the stem which opens the oil passage to full size.

The construction of the burner permits the feeding of a very small or large quantity of oil as well as complete control over the supply of air for combustion.

The burner connections provide for a ½-in. oil line and a 2-in. air line, giving a large range of feed of both oil and air. Air at 2 lb. and oil at 5 lb. per square inch are commonly used, but burners are in operation under a great variety of conditions as to pressure of oil and air.

The California Section of the American Chemical Society met on Jan. 12 in San Francisco and was addressed by Dr. Dorsey A. Lyon of the Bureau of Mines. J. W. Beckman is chairman of the Section.

Scrap Metal Briquetting Machines

A PATENT has recently been issued to Thomas Gilmore, Jr., of Brooklyn, N. Y., on a hydraulic briquetting machine for metal or mineral fines. The patent is assigned to the General Briquetting Co. of 25 Broad St., New York (1,247,667, Nov. 27, 1917). The machine is made by this company and is shown in the general view, Fig. 1. It is known as a horizontal three-stage briquetting press and is made especially for small capacities. It is a development of the Ronay system of metal briquetting which has been installed recently in many plants by the General Briquetting Co. The latter system is intended for larger plants where the output of scrap metal is over two tons per hour. The larger Ronay press is a vertical machine and is shown in Fig. 2. It will produce 6000 to 9600 lb. of briquettes per hour, of cast iron borings, 6-in. diameter and weighing 25 to 40 lb. each. On brass turnings it will produce 1500 to 7500 lb. per hour, the capacity varying with the density of the turning used for briquetting. Pressures from 23,000 to 33,000 lb. per square inch are applied on the briquettes.

The smaller horizontal type of machines, Fig. 1, have a cylindrical packing hopper provided with a swiveled lid. Material is introduced into the hopper intermittently. When the hopper is full the flow is checked and the lid closed, pressing the chips and curls together and getting rid of the surplus air. The operation of the low pressure pumps moves the plunger forward and packs the material into the mold shown at the right. The pressure is built up gradually, thereby allowing the escape of included air. Especial emphasis is laid on this feature.

When the material is thoroughly packed, the second stage begins. The full pressure is gradually built up until a maximum of 25,000 lb. per square inch is realized. A short interval is again allowed to assure permanent set. The pressure is removed. The third stage follows. By means of a lever the rear block of the mold is removed and a comparatively light pressure again applied. The plunge acts as an ejector and forces the finished briquette from the machine. The mold is closed, the plunger drawn back, the hopper opened and operation starts as before. This design is made in two sizes: "B" size, pressure 275 tons, making 6-in. briquettes, capacity ½ to 1 ton per hour, and "C" size, pressure 125 tons, making 4-in. briquettes, capacity ¼ (and less) to ½ ton per hour, depending in each case upon the nature of the material treated.

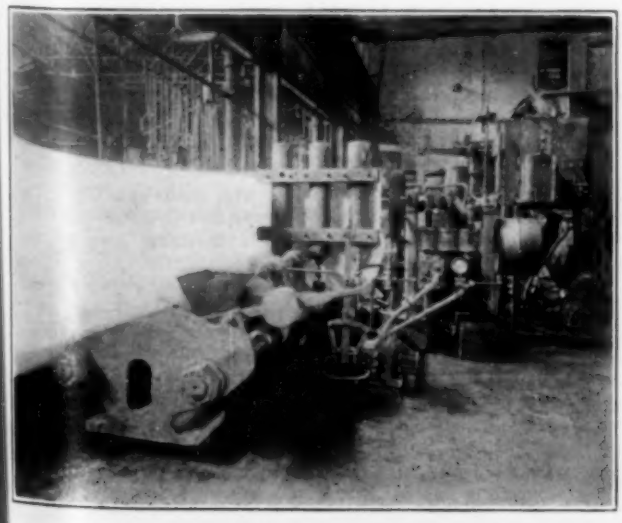


FIG. 1. TYPE "C" BRIQUETTING MACHINE

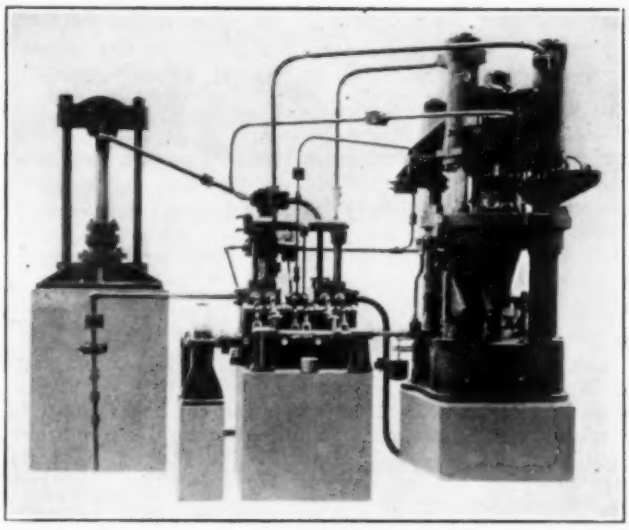


FIG. 2. TYPE "A" METAL BRIQUETTING PRESS, AUTOMATIC HYDRAULIC, SIX MOLD ROTARY PRESS

These presses have been used successfully on brass, aluminium, tin, zinc, lead, cast iron, steel, turnings and borings, sawdust, coal, coke, and various other residues and materials which were to be charged into a furnace. The use of fines in a furnace charge generally entails a heavy loss.

Bronze turnings when compressed into briquettes by this method only occupy one-sixth the original volume. When these briquettes are melted down a much smaller surface is exposed to the air, and the loss by oxidation is greatly reduced, as is also the time required for melting.

New Car Loader

A machine has recently been placed on the market by the Link-Belt Company, of Nicetown, Philadelphia, for loading all kinds of material into box cars. It is shown in the accompanying photograph.

It is a portable machine, driven by motor or gas engine, and handles the material delivered to it through the steel hopper, on a flat belt. On a recent

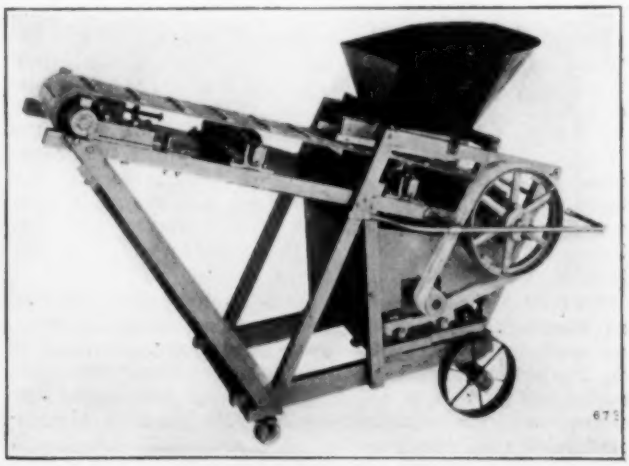


FIG. 1. NEW CAR LOADER

test it loaded 80 box cars in six days with two men. Its capacity is 80 to 100 tons per hour. In the present labor shortage the machine should prove especially valuable.

Personal

Professor WILDER D. BANCROFT of the department of chemistry of Cornell University, is in Washington, serving as technical adviser in the U. S. Bureau of Mines.

The following gentlemen have recently joined the staff of the Powdered Coal Engineering & Equipment Co., Chicago, Ill.; A. N. DETWEILER, consulting engineer; ALEX. L. FEILD, formerly assistant metallurgist at the Lake Superior Station of the Bureau of Mines; W. G. WILCOX, formerly superintendent of the Massena Works of the Aluminum Co. of America.

Dr. W. L. EVANS, a captain in the ordnance department, is organizing a large staff for research work and routine tests in the war department.

Dr. I. W. E. GLATTFELD has been appointed a member of the committee on the supply of organic chemicals for research during the war.

Dr. W. J. LENZ has severed his connection with the Lenz Apparatus Co., Inc., of 9 E. 16th St., New York, in order to devote his time to his manufacturing interests.

Prof. CHARLES E. LOCKE, professor of mining at Massachusetts Institute of Technology, has been appointed to give a course of 45 mining lectures during the last three weeks of January at the Missouri School of Mines, Prof. CARROLL R. FORBES of the latter school having entered military service.

Mr. F. C. NEWTON has resigned as general manager of the Newton Mfg. Company and is now assistant to the general manager of the U. S. Cartridge Company, at Lowell, Mass.

Mr. F. M. NOURSE has joined the advertising department of the Cutler-Hammer Mfg. Co. of Milwaukee in the capacity of technical writer. Mr. Nourse is a graduate of the University of Illinois, 1912, since which time he has been engaged in various branches of engineering work.

Professor W. A. NOYES spoke on the subject "The Development of a Career of Research" before the University of Illinois Section of the American Chemical Society on Jan. 15.

Mr. JOHN F. QUEENY, president of the Monsanto Chemical Company, 1800 South Second Street, St. Louis, Mo., has been elected general manager of the East St. Louis plant of the Commercial Acid Company, to succeed WILLIAM H. COOKE, the president, who has been called away to military service of the United States. The Commercial Acid Company is supplying the government with a large order of medical products.

United States Fuel Administrator Harry A. Garfield has announced the appointment of M. L. REQUA of California to handle oil matters for the United States Fuel Administration. Mr. Requa will have full charge of the activities of the Fuel Administration in connection with oil under the direction of Fuel Administrator Garfield. Since the organization of the United States Food Administration, Mr. Requa has been an assistant to Food Administrator Herbert Hoover. His transfer has been arranged with Mr. Hoover, who has consented to the change because of Mr. Requa's qualifications for his new position.

Mr. GUY E. TRIPP of New York, heretofore chairman of the Westinghouse Electric and Manufacturing Company, has been appointed by the War Department as Chief of the Production Division of the Ordnance Department, intrusted with the task of supervising and stimulating the production of all ordnance supplies. He has been given a commission as Colonel.

Dr. CHARLES H. VIOL, director of the Radium Research Laboratory of the Standard Chemical Co. of Pittsburgh, delivered an address on "Radium and Radio-activity" before the Philadelphia Section of the American Chemical Society on Jan. 17.

Mr. BURTON G. WOOD, formerly of the Monsanto Chemical Works of St. Louis, is now chief chemist of the Intravenons Products Co. of St. Louis, manufacturer of organic arsenic products, etc.

Mr. VICTOR YNGVE has been engaged as research chemist by the Oldbury Electro Chemical Company of Niagara Falls, N. Y., and will have charge of their research laboratory.

Prof. GEORGE J. YOUNG, recently professor of mining in the University of Minnesota, and previously in the Mackay School of Mines at Reno, Nev., has joined the editorial staff of the *Engineering and Mining Journal* as assistant editor-in-chief.

Current Market Reports

Chemical Market

Coal Tar Products.—The crudes for the most part have been quiet of late, but the intermediates have been in better demand than for some time heretofore. Prices in general are unchanged, although with an increased demand for the toluol intermediates, it would not be surprising to see a material increase in prices effective.

Benzol.—While there has been more business closed on contract over the year, there continues to be a good quantity of material offered at low prices. Spot material is not moving in large quantities, transactions in general being confined to small lots.

Toluol.—While a few producers of the intermediates have succeeded in securing releases of small quantities, there does not appear to be any inclination on the part of the authorities to grant general releases of material.

Naphthalene is in light supply; there has been quite a little business done during the past week with prices unchanged.

Benzoate of Soda supplies are light, and stocks for the most part are in speculative hands; prices are soaring by leaps and bounds. Only few producers are offering because of their inability to secure toluol.

Phenol.—There is but little available in the open market the Government having contracted for the majority of the output.

Aniline Oil.—A slightly improved inquiry, together with the scarcity of the necessary acids, has caused a slight advance in price.

Paranitraniline.—Some large sales have been consummated of late, but there continues to be large quantities offered and prices are unchanged.

Beta Naphthol.—There is a fair demand for the technical grade with prices varying but little because of the heavy production. Other grades are in light call and prices are on about the same parity as for some time past.

Aniline Salt.—There are a few offerings at a cent or two under the market, but the situation is quite firm on quantities of moment.

Metanitraniline.—Offerings are liberal and the demand light with prices unchanged.

Para Toluidine has been in better demand, but large factors have not as yet advanced prices, although it is said that some such plan is under way due to the toluol scarcity.

Ortho Toluidine.—Some large orders have been placed, but the price is unchanged.

Tolidin is in ample supply with the demand only fair and but little variation in the price range.

Anthracene is in light supply and large orders at goodly prices have failed to locate material quantities.

Para Nitro Phenol.—Large transactions have passed of late, but competition is keen and prices are unchanged.

Ortho Nitro Phenol continues to be the subject of inquiry from fur dyers and kindred lines, with prices firm.

Salicylic Acid has been more liberally produced, with the buying demand quiet and prices breaking considerably.

Diphenylamine has been in heavy demand, and but few are producing with prices advancing.

Para Amido Phenol has been produced liberally of late, competition is keen and prices have been reduced.

Heavy Chemicals.—The interval as is usual at this time of the year has been quiet but the extraordinary conditions that have prevailed this January have tended to create a still more uncertain condition. Transactions have mostly been for odd lots of material for prompt delivery. Contracts over the year have been neglected to a rather unusual degree. Improvement is looked for during the coming month as the middle of February is ordinarily the turning point.

Caustic Soda.—From the most speculative market in the chemical classification this market has assumed an aspect fully as quiet as any other chemical. Owing to freight difficulties sellers have been somewhat reluctant to quote forward positions but buyers have on the other hand shown but little desire to cover. Caustic soda is well held it is quite evident. Despite the lack of business prices have not declined and some material has commanded from 6½c up. Forward positions are generally obtainable at 6c.

Soda Ash.—This market has been more active than caustic but the total volume of business transpiring has not been very large. Stocks are well held and spot positions have generally commanded 3c., although the figure has been shaded a trifle from time to time. Export barrels have been in urgent request and it seems that export licenses have been granted probably to South American points.

Bichromate of Soda.—There has been a decided flurry in this market charged variously to speculative interests, and then, again, to an export order for some 250 tons concerning which there did not seem to be any definite information possible. In any event sales were rather frequent and passed as high as 20c. for spot. Producers seemingly thought the situation one that warranted higher prices for shipments from the works were advanced from 20c. and in some cases to 22c.

Bichromate of Potash.—In contrast this product has not been easily moved and there have been offers of spot material at 41c., although the general asking price is 43c. and 45c.

Calcium Carbide.—The demand continues far in excess of the supply, and sales, principally for export, are occurring at record high prices. The various sizes are selling at about the same price. Sales have occurred at high as 13½c. From 12½c. to 13½c. covers the market.

Acetic Acids.—The situation has revealed considerable firmness owing to the difficulty of securing raw materials, but there has not been a great deal of activity noted and consumers are rather inclined to hold off.

Cyanide of Soda.—The product has not moved well during the interval, and it has been possible to purchase prompt stocks at comparatively attractive figures. Generally regular sellers quote 43c. to 45c. as to shipping point.

Sulphuric Acid.—The acid situation continues to reveal the same degree of firmness previously noted, but there is not a great deal of activity noted. Some 66 degree brimstone acid has been offered at $40 sellers tanks works January shipment. In drums $45 is generally quoted. A lot of several hundred tons of 60 degree brimstone acid was offered at a New Jersey point at $40 drums for prompt shipment. Oleum has been offered at $75 prompt and $70 January shipment from works.

Nitric Acid.—So far there has been no pronounced movement in nitric acid. From various points there are offers of car quantities of the 42 degree material at 9c. The scarcity of carboys has tended to restrict shipment considerably.

Muriatic Acid.—Heavy government buying of late has created a very firm situation and prices are now much higher than any that have prevailed for a year. Carboys are so scarce that acid consumers have more difficulty in securing packages than the acid itself. Prices vary greatly according to seller and shipping point.

Bleaching Powder.—Slow train movements tend to restrict the market and at the same time tend to lower values. Bleach a month en route is not an attractive buy when fresh material is absolutely necessary. Shipments rolling have generally been available at about 2c. domestic drums but for prompt material from works producers have not been inclined to quote under 2½c.

The Iron and Steel Market

The weather has become the chief topic of conversation in iron and steel circles. The weather determines the volume of transportation and the iron and steel industry depends upon transportation. Fuel Administrator Garfield's order prohibiting the burning of fuel, with certain exceptions, Jan. 18 to 22, inclusive, and nine Mondays thereafter, created a furore in many manufacturing circles, but not in the iron and steel industry, where it was interpreted as a phase of the transportation situation. Some manufacturers stood aghast at the idea of their plants being closed by edict, but the iron and steel industry is used to strenuous things. Breaks in machinery that close plants are no less unexpected, individually, than was Dr. Garfield's order. It was obeyed by the steel industry as fully as physical conditions permitted.

The order was interpreted as permitting blast furnaces to operate, as they would be injured more or less by banking, and coke would be consumed without pig iron being produced, while the congestion in cars loaded with coke would simply be transferred from the neighborhood of production to the neighborhood of consumption. As to the steel-making units there was some question, but as a rule they closed. The rolling of steel ceased except as to exempted products. There was some accumulation of cold ingots, and a larger accumulation of Sunday metal, but there is no curtailment in the long run in the production of finished steel, for there is ample steel-making capacity to absorb the Sunday metal, and the ingots accumulated can be rolled in due course. As to the steel industry, the fuel order postponed the consumption of a great deal of fuel, but it did not effect a net reduction in the consumption. Rather there is in the long run an increase, by reason of the use of Sunday metal and cold ingots.

Transportation Governing Factor

More or less since late in November, 1916, and absolutely in the past few months the production of steel has hinged upon the production of pig iron, and the production of pig iron in turn has hinged upon the supply of coke, the chief restriction in the latter being the insufficient movement of the Connellsville product, next in order being a shortage of coal at by-product ovens. In any event it has been altogether a matter of transportation. Production of pig iron in 1916 was 39,400,000 tons, with several new furnaces completed during the year, and with still more new furnaces completed in 1917 the year's production was only about 38,600,000 tons. The production rate in December was about 34,000,000 tons, and the January rate has been still less. By this time the productive capacity must be close to and quite possibly in excess of 43,000,000 tons. The production of steel ingots in 1916 was 41,400,000 tons. The new capacity added in 1916 and 1917 is rated at over 8,000,000 tons, and could doubtless be counted upon for 7,500,000 tons in actual practice. That part of the 1916 production attributable to capacity in existence at the beginning of the year was fully 40,000,000 tons, hence capacity at the end of 1917 may be taken at 47,500,000 tons, but the monthly report of the American Iron and Steel Institute shows production in December, 1917, at the rate of only 37,000,000 tons. Production in January up to the time of the fuel order was at a still lower rate. All this restriction is shortage of pig iron, this in turn being shortage of coke and this in turn shortage of transportation.

The situation represents not a slight restriction but a great breakdown in the matter of transportation. Last year's coal production, almost adequate, was 544,000,000 net tons of bituminous coal and 100,000,000 net tons of anthracite, or 644,000,000 tons altogether. A liberal estimate is an average haul of 100 miles, since most industries have located close to their fuel. That is 65,000,000,000 ton-miles of freight movement, and in the five months ended last August the railroads conducted transportation at the rate of 425,000,000,000 ton-miles a year. The coal movement represents only 15 per cent of movement at last summer's rate, and under Government control, with various restrictions removed, the railroads are expected to do still better. Connellsville coke movement has lately been short by an average of about 75,000 tons a week, representing about 5,000,000,000 ton-miles of movement, or less than

one-eighth of one per cent of the railroads' normal capacity. The shortage of by-product coal represents probably a still smaller fraction.

The conditions described have been bad enough, but in recent weeks there has been the additional restriction of shortage of cars for moving finished steel, and then a large number of embargoes, with permits granted only occasionally. Despite the restriction in production caused by insufficiency of raw material, it has been impossible to ship the product, and finished steel has accumulated in warehouses and yards to such an extent that any considerable further accumulation is impossible, and departments are closing because they cannot ship their product.

In the circumstances there is no market to discuss and the trade thinks only of weather prospects. Steel shipments in January have represented only about half the capacity. With favorable weather, which cannot be many weeks distant, conditions may be entirely different. March is traditionally a record month for both pig-iron and steel production.

By Washington's edict of Dec. 29 the matter of iron and steel price revision will come up not later than March 31, but current events are manufacturing no testimony as to what should then be done. Cost of production at a time like this could not be used as a measure of what would be right prices in the future. One thing clear is that if Washington desires lower prices for pig iron and steel, the fair and efficient method of preparing the way is to seek first conditions that will permit orderly and economic production.

Non-Ferrous Metal Market

Friday, Jan. 25.—There has been very little activity in any of the markets during the past two weeks, and prices show little variation with the exception of tin which is still scarce and higher.

Copper.—The President has announced his approval of the recommendation of the War Industries Board that the maximum price for copper be continued at 23½ cents per pound f.o.b. New York until June 1, 1918. This price is subject to revision after June 1, 1918, upon the conditions, first, that the producers will not reduce the wages now being paid; second, that the producers will sell to the allies and to the public copper at the same price paid by the Government, and take the necessary measures under the direction of the War Industries Board for the distribution of the copper to prevent it from falling into the hands of speculators who would increase the price to the public; and, third, that the producers pledge themselves to exert every effort necessary to keep up the production of copper to the maximum of the past, so long as the war lasts. At the present writing it was difficult to buy electrolytic copper for February delivery. Casting copper is more freely offered. The jobbers' price remains at 24.67½ cents, New York.

Tin.—The tin market is unsettled and actual quotations are hard to give as no tin is offered for sale. The Emergency Fleet Corporation commandeered the pig tin stores in New York on Jan. 23, presumably for distribution to concerns having urgent need of the tin to finish war orders. The arrivals so far this month are only 1065 tons which is about one-fifth normal. England is still holding up shipping permits.

Lead.—The market has been very dull and the Trust price remains at 6.75 cents, with independents asking 7 cents. Very little metal is offered for sale. Transportation problems and the fact that some producers are sold up have combined to make the inactive market. Also, consumers are not bidding heavily.

Spelter.—There is not much to be said about the spelter market. Buyers do not show much interest and the market is very dull. The average quotation at New York now is about 7.82½ cents for Prime Western. Nothing has been done to fix prices on ordinary grades of spelter as yet and producers maintain that they cannot produce at a profit under 10 cents. The price on high grade spelter is adjusted by the Zinc Committee and War Industries Board.

Tungsten.—Scheelite has been offered more freely owing to arrivals from California and South America. Prices average about $24.50 for 65 per cent material.

Molybdenum.—The Canadian embargo on molybdenite has been raised and arrivals have been large, selling at $2.15 to $2.20 per pound for 85 per cent material.

Chromium.—Chrome ore is scarce and high prices are asked. Ferrochromium will probably go higher.

Quicksilver.—California material is offered at $130 per flask with Mexican at $125.

OTHER METALS

Aluminium, lb.	.36–.38
Bismuth, lb.	3.00–3.50
Cadmium, lb.	1.50
Nickel, electrolytic, lb.	.55
Silver, oz.	.87⅜
Platinum, oz.	105.00
Palladium, oz.	130.00–135.00
Cobalt, lb.	3.25–3.50
Magnesium	2.00

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET, JAN. 24, 1918

Acetic anhydride	lb.	Nominal		
Acetone, drums	lb.	Nominal		
Acid, acetic, 28 per cent	lb.	.05½	—	.06
Acetic, 56 per cent	lb.	.11¼	—	.12
Acetic, glacial, 99½ per cent, carboys	lb.	.34	—	.35
Boric, crystals	lb.	.13¼	—	.14¼
Citric, crystals	lb.	.75	—	.78
Hydrochloric, C. P.	lb.	Nominal		
Hydrochloric, 20 deg.	lb.	Nominal		
Hydrochloric, conc., 22 deg.	lb.	Nominal		
Hydrofluoric, 30 per cent, in barrels	lb.	.06¼	—	.06½
Lactic, 44 per cent	lb.	.15	—	.15½
Lactic, 22 per cent	lb.	.05½	—	.06½
Nitric, 36 deg.	lb.	.09	—	.10
Nitric, 42 deg.	lb.	.09	—	.10
Oxalic, crystals	lb.	.44	—	.45
Phosphoric, 47 per cent-50 per cent crude	lb.	.07	—	.07½
Phosphoric, ref. 50 per cent	lb.	.26	—	.....
Picric	lb.	Nominal		
Pyrogallic, resublimed	lb.	3.15	—	3.25
Sulphuric, 60 deg.	ton	.....	—	.....
Sulphuric, 66 deg.	ton	40.00	—	45.00
Sulphuric, oleum (Fuming), tank cars	ton	70.00	—	80.00
Tannic, U. S. P., bulk	lb.	1.30	—	1.35
Tartaric, crystals	lb.	.78	—	.80
Tungstic, per lb. of W	lb.	1.80	—	1.90
Alcohol, sugar cane, 188 proof	gal.	5.05	—	5.25
Alcohol, wood, 95 per cent	gal.	1.35	—	.....
Alcohol, denatured, 180 proof	gal.	.78	—	.80
Alum, ammonia lump	lb.	.04½	—	.05
Alum, chrome ammonium	lb.	.18	—	.19
Alum, chrome potassium	lb.	.23	—	.25
Alum, chrome sodium	lb.	.12½	—	.13
Alum, potash lump	lb.	Nominal		
Aluminium sulphate, technical	lb.	.01⅞	—	.02
Aluminium sulphate, iron free	lb.	.02¾	—	.03
Ammonia aqua, 26 deg. carboys	lb.	.20	—	.....
Ammonium carbonate	lb.	.11	—	.12
Ammonium nitrate	lb.	(Fixed price)		.14
Ammonium, sulphate domestic	lb.	.07¼	—	.07½
Amyl acetate	gal.	5.25	—	5.40
Arsenic, white	lb.	.16¼	—	.16½
Arsenic, red	lb.	.65	—	.70
Barium carbonate, 99 per cent	ton	80.00	—	90.00
Barium carbonate, 97-98 per cent	ton	65.00	—	67.00
Barium chloride	ton	70.00	—	90.00
Barium sulphate (Blanc Fixe, powder)	lb.	.03½	—	.04
Barium nitrate	lb.	.09½	—	.11
Barium peroxide, basis 70 per cent	lb.	.31	—	.34
Bleaching powder, 35 per cent chlorine	lb.	.02½	—	.02¾
Borax, crystals, sacks	lb.	.07¼	—	.08¼
Brimstone, crude	ton	Nominal		
Bromine, technical	lb.	.65	—	.70
Calcium, acetate, crude	lb.	Nominal		
Calcium, carbide	lb.	.12½	—	.13
Calcium chloride, 70-75 per cent, fused, lump	ton	22.00	—	23.00
Calcium peroxide	lb.	1.60	—	1.70
Calcium phosphate	lb.	.30	—	.31
Calcium sulphate	lb.	.....	—	.....
Carbon bisulphide	lb.	.07	—	.07½
Carbon tetrachloride, drums	lb.	.14	—	.16
Carbonyl chloride (phosgene)		.....	—	.....
Caustic potash, 88-92 per cent	lb.	.83½	—	.84
Caustic soda, 76 per cent	lb.	.06½	—	.06¾
Chlorine, liquid	lb.	.15	—	.18
Cobalt oxide	lb.	1.40	—	1.50
Copperas	lb.	.01¼	—	.01½
Copper carbonate	lb.	.45	—	.....
Copper cyanide	lb.	.75	—	.78
Copper sulphate, 99 per cent, large crystals	lb.	.09	—	.09½
Cream of tartar, crystals	lb.	.61	—	.63
Epsom salt, bags	lb.	.03½	—	.03¼
Formaldehyde, 40 per cent	lb.	.19½	—	.20
Glauber's salt	100 lb.	1.00	—	1.10
Glycerine, bulk, C. P.	lb.	.67½	—	.70
Iodine, resublimed	lb.	4.25	—	4.35
Iron oxide	lb.	.13	—	.15
Lead, acetate, white crystals	lb.	.17	—	.17½
Lead arsenate (Paste)	lb.	.15	—	.18
Lead nitrate	lb.	Nominal		
Litharge, American	lb.	.09½	—	.11½
Lithium carbonate	lb.	1.50	—	2.00
Manganese dioxide, U. S. P.	lb.	.70	—	.75
Magnesium carbonate, technical	lb.	.10	—	.10½
Nickel salt, single	lb.	Nominal		
Nickel salt, double	lb.	Nominal		
Phosgene, see Carbonyl chloride		.....	—	.....
Phosphorus, red	lb.	1.60	—	1.70
Phosphorus, yellow	lb.	1.25	—	.....
Potassium bichromate	lb.	.43	—	.45
Potassium bromide granular	lb.	1.45	—	1.50

Potassium carbonate calcined, 85-90 per cent	lb.	.60	—	.65
Potassium chlorate, crystals	lb.	.40	—	.42½
Potassium cyanide, 98-99 per cent	lb.	Nominal		
Potassium iodide	lb.	3.75	—	3.80
Potassium muriate 80-85 p. c. basis of 80 p. c	ton	350.00	—	.....
Potassium nitrate	lb.	.30	—	.32
Potassium permanganate (U. S. P.)	lb.	4.00	—	4.10
Potassium prussiate, red	lb.	2.60	—	2.70
Potassium prussiate, yellow	lb.	1.27	—	1.30
Potassium sulphate, 90-95 p.c. basis 90 p.c	ton	Nominal		
Rochelle salts	lb.	.39	—	.39½
Salammoniac, gray gran	lb.	.15	—	.16
Salammoniac, white gran	lb.	.15	—	.16
Sal soda	100 lb.	1.25	—	1.30
Salt cake	ton	22.00	—	23.00
Silver cyanide, based on market price of silver	oz.	.....	—	.....
Silver nitrate	oz.	.53	—	.55
Soda ash, 58 per cent, light, flat	100 lb.	2.95	—	3.00
Soda ash, 58 per cent, dense, flat	100 lb.	3.50	—	4.00
Sodium acetate	lb.	.16½	—	.17
Sodium bicarbonate, domestic	lb.	.02⅝	—	.03
Sodium bicarbonate, English	lb.	.....	—	.....
Sodium bichromate	lb.	.19½	—	.20
Sodium bisulphite, powd	lb.	.06¼	—	.06½
Sodium chlorate	lb.	.20	—	.22
Sodium cyanide	lb.	.42	—	.44
Sodium fluoride, commercial	lb.	.18½	—	.....
Sodium hyposulphite	lb.	.02½	—	.....
Sodium molybdate, per lb. of Mo	lb.	2.50	—	.....
Sodium nitrate, 95%	100 lb.	4.50	—	.....
Sodium nitrite	lb.	.30	—	.35
Sodium peroxide	lb.	.49	—	.50
Sodium phosphate	lb.	.04	—	.04½
Sodium prussiate, yellow	lb.	.37	—	.38
Sodium silicate, liquid (60 deg.)	lb.	.03½	—	.04½
Sodium sulphide, 30 per cent., crystals	lb.	.02¾	—	.03
Sodium sulphide, 60 per cent., fused	lb.	.04⅞	—	.05
Sodium sulphite	lb.	.05	—	.06
Strontium nitrate	lb.	.25	—	.35
Sulphur chloride, drums	lb.	.06	—	.06½
Sulphur dioxide, liquid, in cylinders	lb.	.15	—	.40
Sulphur, flowers, sublimed	100 lb.	4.05	—	4.10
Sulphur, roll	100 lb.	3.70	—	3.85
Sulphur, crude	ton	Nominal		
Tin bichloride, 50 deg	lb.	Nominal		
Tin oxide	lb.	.75	—	.90
Zinc carbonate	lb.	.22	—	.25
Zinc chloride	lb.	.10½	—	.11
Zinc cyanide	lb.	Nominal		
Zinc dust, 350 mesh	lb.	.17	—	.18
Zinc oxide, American process XX	lb.	.13½	—	.14
Zinc sulphate	lb.	.06	—	.07

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.35	—	.40
Benzol, 90 per cent	gal.	.....	—	.....
Toluol, pure water white	gal.	Nominal		
Xylol, pure, water white	gal.	.35	—	.50
Solvent naphtha, water white	gal.	.17	—	.22
Solvent naphtha, crude, heavy	gal.	.13	—	.16
Creosote oil, 25 per cent	gal.	.33	—	.35
Dip oil, 20 per cent	gal.	.29	—	.30
Pitch, various grades	ton	8.00	—	20.00
Carbolic acid, crude, 95-97 per cent	lb.	1.05	—	1.10
Carbolic acid, crude, 50 per cent	lb.	.60	—	.65
Carbolic acid, crude, 25 per cent	lb.	.35	—	.38
Cresol, U. S. P	lb.	.18	—	.20

Intermediates, Etc.

Alpha naphthol, crude	lb.	1.10	—	.....
Alpha naphthol, distilled	lb.	1.60	—	.....
Alpha naphthylamin	lb.	.58	—	.60
Aniline oil, drums extra	lb.	.26	—	.28
Aniline salts	lb.	.32	—	.34
Anthracene, 80 per cent	lb.	.50	—	.65
Benzaldehyde	lb.	4.00	—	4.50
Benzidine, base	lb.	1.75	—	1.85
Benzidine, sulphate	lb.	1.40	—	1.50
Benzoic acid U. S. P	lb.	.....	—	.....
Benzoate of Soda, U. S. P	lb.	5.45	—	5.75
Benzyl chloride	lb.	1.75	—	1.85
Beta naphthol benzoate	lb.	7.00	—	8.00
Beta naphthol, sublimed	lb.	.85	—	.90
Beta naphthylamin com	lb.	2.50	—	2.65
Dichlor benzol	lb.	.12	—	.18
Diethylaniline	lb.	4.00	—	5.00
Dinitro benzol	lb.	.34	—	.50
Dinitrochlorbenzol	lb.	.40	—	.42
Dinitronaphthaline	lb.	.55	—	.60
Dinitrotoluol	lb.	.55	—	.60
Dinitrophenol	lb.	.55	—	.57
Dimethylaniline	lb.	.57	—	.62
Diphenylamine	lb.	.85	—	1.00
H-acid	lb.	2.25	—	2.50
Metaphenylenediamine	lb.	1.85	—	2.00
Monochlorbenzol	lb.	.19	—	.22
Naphthalene, flake	lb.	.09½	—	.09¾
Naphthalene, balls	lb.	.10½	—	.10¾
Naphthionic acid, crude	lb.	1.40	—	1.50
Naphthylamin-di-sulphonic acid	lb.	1.00	—	1.10
Nitro naphthaline	lb.	.45	—	.50
Nitro toluol	lb.	.50	—	.55
Ortho-amidophenol	lb.	.....	—	.....
Ortho-toluidine	lb.	1.00	—	1.20
Ortho-nitro-toluol	lb.	.75	—	1.00
Para-amidophenol, base	lb.	3.50	—	4.00
Para-amido-phenol, H. Cl	lb.	4.00	—	4.25
Paranitraniline	lb.	1.05	—	1.15
Para-nitro-toluol	lb.	1.50	—	1.60
Paraphenylenediamine	lb.	3.00	—	3.50
Para toluidine	lb.	2.25	—	2.50
Phthalic acid anhydride	lb.	4.50	—	6.50
Phenol, U. S. P	lb.	.53½	—	.55
Resorcin, technical	lb.	6.00	—	7.00
Resorcin, pure	lb.	10.00	—	12.00
Salicylic acid	lb.	1.05	—	1.10
Salol	lb.	1.85	—	2.00
Sulphanilic acid	lb.	.32	—	.35
Tolidin	lb.	2.50	—	.....
Toluidine-mixture	lb.	.75	—	.85

Petroleum Oils

Crude (at the Wells)

Pennsylvania	bbl.	3.75	—	.....
Corning, Ohio	bbl.	2.80	—	.....
Somerset, Ky	bbl.	2.55	—	.....
Wooster, Ohio	bbl.	2.38	—	.....
Indiana	bbl.	1.98	—	.....
Illinois	bbl.	2.12	—	.....
Oklahoma and Kansas	bbl.	2.00	—	.....
Caddo, La., light	bbl.	2.00	—	.....
Corsicana, Tex., light	bbl.	2.00	—	.....
California	bbl.	.98	—	1.32
Gulf Coast	bbl.	1.00	—	.....

Fuel Oil

New York	gal.	.11	—	.....
Pittsburgh	gal.	.07½	—	.10
Oklahoma-Kans	bbl.	1.50	—	2.35
Texas	bbl.	1.50	—	1.75
Los Angeles	bbl.	1.52	—	.....
San Francisco	bbl.	1.45	—	.....

Gasoline (Wholesale)

New York	gal.	.24	—	.....
Boston	gal.	.25	—	.....
Pittsburgh	gal.	.26	—	.....
Chicago	gal.	.21	—	.....
Oklahoma	gal.	.25	—	.....
San Francisco	gal.	.20½	—	.....

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.19	—	.20
Cylinder, light	gal.	.34	—	.35
Cylinder, dark	gal.	.33	—	.34
Paraffine, high viscosity	gal.	.36	—	.37
Paraffine, 903 sp. gr	gal.	.29	—	.30
Paraffine, .865 sp. gr	gal.	.21	—	.22

Flotation Oils

(Prices at New York unless otherwise stated)

Pine oil, crude, f.o.b. Florida	gal.	.44	—	.....
Pine oil, steam distilled, sp. gr. 0.925-0.940	gal.	.50	—	.....
Pine oil, destructively distilled	gal.	.43	—	.53
Pine-tar oil, sp. gr., 1.025-1.035	gal.	.30	—	.....
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal.	.35	—	.....
Pine oil, light, sp. gr. 0.950, tank cars, f.o.b. works	gal.	.37	—	.....
Pine oil, heavy, sp. gr. 1.025, tank cars, f.o.b. works	gal.	.26	—	.....
Pine tar, thin, sp. gr. 1.060-1.080	gal.	.32	—	.....
Turpentine, crude, sp. gr. 0.980-1.000	gal.	.40	—	.....
Hardwood oil, f.o.b. Michigan, sp. gr. 0.960-0.990	gal.	.21	—	.....
Hardwood oil, f.o.b. Michigan, sp. gr. 1.06-1.08	gal.	.19½	—	.....
Wood creosote, ref. f.o.b. Florida	gal.	.31	—	.....

Vegetable and Other Oils

China wood oil	lb.	.20	—	.21
Cottonseed oil, crude	lb.	.17½	—	.18
Linseed oil, raw, cars	gal.	1.28	—	.....
Peanut oil, crude	gal.	1.37	—	.....
Rosin oil, first run	gal.	.35	—	.....
Rosin oil, fourth run	gal.	.66	—	.....
Soya bean oil, Manchuria	lb.	.18	—	.18½
Turpentine, spirits	gal.	.50	—	.51

Miscellaneous Materials

Barytes, floated, white, foreign	ton	40.00	—	50.00
Barytes, floated, white, domestic	ton	30.00	—	36.00
Beeswax, white, pure	lb.	.56	—	.64
Casein	lb.	.22	—	.30
Chalk, light, precipitated, English	lb.	.....	—	.....
Feldspar	ton	8.00	—	12.00
Fuller's earth, powdered	100 lb.	1.00	—	1.50
Ozokerite, crude, brown	lb.	.65	—	.75
Ozokerite, American, refined, white	lb.	.75	—	1.00
Red lead, dry, carloads	lb.	.10	—	.11¼
Rosin, 280 lb	bbl.	6.95	—	.....
Soapstone	ton	10.00	—	12.50
Talc, American, white	ton	15.00	—	22.00
White lead, dry	lb.	.09	—	.10

Refractories, Etc.

(F.O.B. Works)

Chrome brick	net ton	Nominal		
Chrome cement, Grecian	net ton	Nominal		
Clay brick, 1st quality fireclay	per 1000	50.00	—	55.00
Clay brick, second quality	per 1000	35.00	—	40.00
Magnesite, raw	ton	30.00	—	35.00
Magnesite, calcined	ton	40.00	—	55.00
Magnesite, Grecian, dead burned	net ton	85.00	—	90.00
Magnesia brick, Grecian, 9x4½x2½	net ton	135.00	—	140.00
Silica brick	per 1000	50.00	—	60.00

Ferroalloys

Ferrocarbontitanium, 15-18 per cent, carloads, f.o.b. Niagara Falls, N. Y	ton	160.00	—	.....
Ferrochromium, per lb. of Cr	lb.	.50	—	.....
Ferromanganese, domestic	ton	250.00	—	.....
Ferromanganese, English	ton	325.00	—	.....
Ferromolybdenum, per lb. of Mo	lb.	5.00	—	.....
Ferrosilicon, 75 per cent, f.o.b. N. Y	ton	.....	—	.....
Ferrosilicon, 50 per cent, carloads, del., Pittsburgh	ton	165.00	—	175.00
Ferrosilicon, 50 per cent, contract	ton	100.00	—	175.00
Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh	lb.	2.35	—	2.45
Ferrouranium, f.o.b. works, per lb. of U	lb.	7.00	—	.....
Ferrovanadium, f.o.b. works	lb.	3.50	—	4.50

Ores and Semi-finished Products

Antimony ore, per unit		1.60	—	1.75
Chrome ore, 48 per cent minimum, f.o.b. Cal., per unit	ton	1.50	—	.....
Manganese ore, 48 per cent and over, per unit	ton	1.20	—	.....
Manganese ore, chemical	ton	80.00	—	100.00
Molybdenite, per lb. of MoS_2	lb.	2.15	—	2.20
Tungsten, Scheelite, per unit of WO_3	ton	24.50	—	.....
Tungsten, Wolframite, per unit of WO_3	ton	24.50	—	.....
Uranium oxide, 96%	lb.	3.25	—	3.60
Vanadium pentoxide, 99%	lb.	10.50	—	.....
Pyrites, foreign	unit	.16	—	.16½
Pyrites, domestic	unit	.25	—	.30

INDUSTRIAL

Financial, Construction and Manufacturers' News

New Companies

ALVORD & FRENSDORF, INC., Syracuse, N. Y. Capital, $200,000. To engage in the manufacture of fertilizer, glue, etc. Incorporators: S. and C. B. Frensdorf, and J. Buff, 112 Warner Street, Syracuse.

THE ATLAS PRODUCTS COMPANY, Chicago, Ill. Capital, $25,000. To engage in a general potash production business. Incorporators: B. Prentiss, P. Zak, and B. F. Cowan, Chicago.

BAMBERGER & ROBBINS, INC., Wilmington, Del. Capital, $50,000. To manufacture paints, varnishes, etc. Incorporators: James McClafferty, James P. Robbins and Samuel Waity, Wilmington.

THE BARNES CHEMICAL WORKS, Paterson, N. J. Capital, $250,000. To manufacture chemicals and allied products. Incorporators: John W., H. J., and L. E. Laffey, Paterson.

THE BERGOLI PRODUCTS COMPANY, New York. Capital, $10,000. To manufacture chemicals, dyestuffs, and kindred products. Incorporators: J. M. Barry, A. C. Thiel and J. L. Fox, 571 West One Hundred and Fifty-ninth Street.

THE BIG SHOT LEAD & ZINC COMPANY, Ardmore, Okla. Capital, $50,000. To mine for lead and zinc. Incorporators: B. S. Curtis, A. T. West, and D. K. Pope, Ardmore.

THE BINDER PAPER BOX COMPANY, Newark, N. J. Capital, $25,000. To manufacture paper boxes, etc. Incorporators: E. Herman, Harry Levin, and K. Fitzgerald, Newark.

THE BLAST FURNACE PRODUCTS CORPORATION, Dover, Del. Capital, $1,000,000. To manufacture apparatus for blast furnaces, etc. Incorporators: Joseph Mann, Bloomfield, N. J.; Arthur P. McKinstry, New York; and Erwin B. Hallett, Brooklyn, N. Y.

THE CALDWELL GLASS COMPANY, Pittsburgh, Pa. Capital, $25,000. To manufacture glassware of various kinds. H. P. Fitzpatrick is the principal incorporator.

THE CENTURY MINING COMPANY, Miami, Okla. Capital, $300,000. To engage in a general lead and zinc business. Incorporators: L. B. Parker and George Weems, Miami, and G. H. Ennis, Mounds, Okla.

THE CONNORS STEEL COMPANY, Birmingham, Ala. Capital, $300,000. To construct and operate a rolling mill for the manufacture of steel hoops, bars, bands, channels, and other steel products. Incorporators: George W. Connors, W. M. Hoke, and S. S. Paul.

THE COMMERCIAL STEEL CASTINGS COMPANY, Marion, Ohio. Capital, $150,000. To manufacture open-hearth steel castings. Incorporators: J. D. Owen, C. A. Owen, D. W. Evans, George D. Copeland, M. C. McNeil, R. H. Beidenbaugh, and H. J. Barnhart.

THE COOSA CARBON COMPANY, Birmingham, Ala. Capital, $150,000. To engage in the development of graphite properties. Incorporators: H. W. Blake, W. A. Neal, P. McGeever, and Robert T. Epperson.

THE CHARLES E. DAVIS FOUNDRY COMPANY, INC., Rutland, Vt. Capital, $75,000. To operate a local foundry. Incorporators: Charles E. Davis, M. I. Mullin, and J. N. Page, Rutland.

JAMES H. DEDERICKS' SONS, INC., Jersey City, N. J. Capital, $30,000. To smelt, refine and deal in gold, silver and other metals. Incorporators: C. A. Cole, Arthur R. Oakley, Paul E. Birtsch, Jersey City.

EDINBURG PAINT & MANUFACTURING COMPANY, Edinburg, Va. Capital, $200,000. To manufacture paints, varnishes, etc.

THE FEDERAL PAPER CAN & CARTON COMPANY, New York. Capital, $10,000. To manufacture paper boxes and other paper specialties. Incorporators: C. C. Wippman, L. S. Lockhart, and E. C. Cushman, 51 Chambers Street.

THE FLORIDA GLASS COMPANY, Tampa, Fla. Capital, $250,000. To manufacture glass and glassware of various kinds. Incorporators: C. J. Earley, Paul T. Davis, and L. M. Stahl, Tampa.

THE GASOLINE ECONOMY COMPANY, Dover, Del. Capital $100,000. To manufacture devices for the use of oil and products thereof.

THE GOLDEN SPIKE MINING COMPANY, Oklahoma City, Okla. Capital, $125,000. To mine for lead and zinc. Incorporators: R. H. Drenna, F. E. Herrin, and O. D. Halsell.

THE HENDERSON PLANTATION COMPANY, Memphis, Tenn. Capital, $500,000. To operate cotton gins, cotton seed oil mills, etc. Incorporators: Frank Hayden, L. K. Salsbury, and J. S. Shortle, Memphis.

THE HOFFMAN PERRY IRON & STEEL COMPANY, Youngstown, Ohio. Capital, $75,000. To operate a plant for the manufacture of iron and steel products. Incorporators: L. J., and Frank C. Hoffman, Youngstown.

THE HUGO BRAND LEATHER COMPANY, New York. Capital, $25,000. To manufacture leather and leather specialties. Incorporators: L. R. Benjamin, E. B., and H. Brand, 622 West One Hundred and Thirteenth Street, New York.

THE IRON CITY FOUNDRY COMPANY, Hamilton, Ohio. Capital, $50,000. To operate a local plant. Incorporators: Albert D. Stuckey and C. E. Freeman.

THE C. E. ISING CORPORATION, New York. Capital, $100,000. To manufacture chemicals and allied products. Incorporators: C. T. Johnson, Youngstown, O., and F. Baer, 550 West One Hundred and Seventy-eighth Street, New York.

THE JOPLIN-MIAMI LEAD & ZINC COMPANY, Oklahoma City, Okla. Capital, $100,000. To engage in a general mining business for the production of lead, zinc, etc. Incorporators: E. M. Butler, R. E. Burks, Oklahoma City, and E. Carman, Springfield, Mo.

THE KINGSPORT WOOD REDUCTION COMPANY, Chicago, Ill. Capital, $2,000,000. To reduce, distill, and treat wood. Incorporators: Harry H. Phillips, Charles J. Horn, and Burrell J. Cramer, Chicago.

THE KETOL COMPANY, Newark, N. J. Capital, $50,000. To engage in the production of coal and wood tars. Incorporators: Charles S. Coe, East Orange; John H. Yocum, Newark, and Lewis M. DeForge, South Orange.

THE LA NORA MINING COMPANY, Chitwood, Mo. Capital, $48,000. To mine for lead and zinc. Incorporators: George G. Bayless, Carterville; Phil Gray, Webb City, Mo.

THE F. G. LASHER COMPANY, Brooklyn, N. Y. Capital, $75,000. To manufacture chemicals, dyestuffs, etc. Incorporators: F. W. Parker, C. Dosher, and F. G. Lasher, 104 Grove Street, Brooklyn

THE EDGAR LEVINSTEIN COMPANY, Boston, Mass. Capital, $250,000. To manufacture chemicals and allied products. Incorporators: Harry R. Davies, Edgar Levinstein, and George L. Bishop, Boston.

THE LOCKPORT LEAD MINING COMPANY, Owenton, Ky. Capital, $30,000. To mine for lead, etc. Incorporators: J. T. Walker, H. C. Green, Sr., N. E. Foster, and F. H. Brown, Owenton.

THE LOOKOUT PAINT COMPANY, Chattanooga, Tenn. Capital, $100,000. To manufacture paints, varnishes, etc. J. H. Stewart is the principal incorporator.

THE LUCKY PAT MINING COMPANY, Miami, Okla. Capital, $150,000. To mine for lead, zinc, etc. Incorporators: L. C. Kropp, Vinita, Okla.; O. O. Snyder, and S. H. Mates, Pryor, Okla.

THE MENDLESON CORPORATION, Albany, N. Y. Capital, $2,000,000. To manufacture potash, chemicals, lime, etc. Incorporators: I. Mendleson, J. and L. Mendleson, 644-A Madison Avenue, Albany.

THE METALS & CHEMICAL CORPORATION, Dover, Del. Capital, $100,000. To manufacture chemicals, colors, dyes, etc.

THE MIAMI ZINC & LEAD COMPANY, Portland, Me. Capital, $3,000,000. To mine for zinc and lead. Incorporators: E. V. Mann, E. H. Irwin, and C. D. Booth.

THE MO-VA-CU PRODUCTS CORPORATION, New York. To manufacture chemicals, oils, etc. Incorporators: C. A. Rucker, Jr., J. J. Haesler, and W. A. White, 229 West One Hundred and Ninth Street, New York.

THE NATIONAL STEEL BARREL COMPANY, Cleveland, Ohio. Capital, $200,000. To manufacture steel products. Incorporators: P. R. Long, C. F. Schriner, John A. Nally, and J. J. Schriner.

THE NORTH CAROLINA TIN COMPANY, Cherryville, N. C. Capital, $100,000. To manufacture tin. Incorporators: M. S. Mauney, D. A. Rudisill, and N. A. Stroup.

THE NATURAL CHEMICAL PRODUCT COMPANY, Lexington, N. C. Capital, $350,000. To manufacture chemicals and allied products, mainly potash from feldspar. Incorporators: C. Berg, of New York, president-chemist; G. W. Mountcastle, vice-president; W. L. Crawford, secretary-treasurer, both of Lexington.

THE PITTSBURGH THERMOLINE COMPANY, Pittsburgh, Pa. Capital, $100,000. To manufacture compressed liquid gas for the welding of iron and other metals. Incorporators: John P., Harry O., and Walter E. Eichleay, Pittsburgh.

THE RAINBOW MINING & DEVELOPMENT COMPANY, Miami, Okla. Capital, $25,000. To engage in a general mining business. Incorporators: F. E. Atchiet, W. A. Spurlin, and R. M. Radcliffe, all of Erick, Okla.

THE RED-OINT-A CHEMICAL COMPANY, Portland, Me. Capital, $10,000. To manufacture chemicals, etc. Incorporators: A. M. Brown, Winchester, Mass.; W. D. Hobson, Portland.

THE SHARTEL MINING COMPANY, Oklahoma City, Okla. Capital, $25,000. To mine for lead and zinc. Incorporators: Charles Hoopes, J. W. Shartel, and W. C. Jones, Oklahoma City.

THE SHUTTLEWORTH-WOLLNY COMPANY, New York. Capital, $10,000. To manufacture paper, paper boxes, etc. Incorporators: C. J. Wollny, F. Keiller, and W. E. Shuttleworth, 474 West Broadway, New York.

DAVID H. SMITH & SONS, INC., Brooklyn, N. Y. Capital, $100,000. To manufacture iron and steel products. Incorporators: D. H. Smith, Mahwah, N. J.; M. F. Smith, Brooklyn, N. Y.; and J. C. Snyder, 256 Broadway, New York.

THE STAMBAUGH IRON COMPANY, Cleveland, Ohio. Capital, $10,000. To operate a local iron works. Incorporators: F. McKenzie and F. J. Moriarity.

Construction and Operation

Alabama

BESSEMER.—The National Steel Products Company has recently acquired a large piece of property and is planning for the immediate construction of a new plant. It is expected to have the works completed and ready for operation within three months.

Arizona

VERDE.—The United Verde Extension Mining Company is having plans prepared for all buildings required for the new townsite at its local smelter. Sewer, water, and electric lighting system will also be installed, the entire work being estimated to cost approximately $2,000,000.

RAY.—The Ray-Hercules Copper Company is rushing to completion the erection of its new initial mill unit, and is planning to inaugurate operations at an early date. When completed, the first unit of the plant will have a capacity of 1,500 tons of ore daily.

Arkansas

NORTH LITTLE ROCK.—Fire recently destroyed a large portion of the Buckeye Cotton Oil Mill of the Procter & Gamble Soap Company, Cincinnati, Ohio, with loss said to be approximately $400,000. It is reported that the works will be immediately rebuilt. A. B. Carr is manager.

LITTLE ROCK.—The Arkansas Foundry Company has acquired property at the foot of East Sixth Street, and is planning for the establishment of a new foundry for the production of gray iron castings for railroad construction, to have a capacity of about 15 tons daily.

YELLVILLE.—The Deep Mining Company, recently organized, is plannnig for the early development of deep ore bodies on Cowan Barrens, between Yellville and the Rush mining camp on Buffalo River.

California

MARTINEZ.—The Atlas Powder Company is said to be planning for the construction of a large addition to its Giant Powder plant. The company has recently acquired a site consisting of about 200 acres of land adjoining the works.

SAN DIEGO.—The United States Government, Navy Department, has awarded a contract to John W. Danforth Company, 70 Ellicott Square, Buffalo, N. Y., for the

construction of a new local concrete and steel fuel oil plant, to cost about $275,000.

OAKLAND.—The Judson Manufacturing Company is making rapid progress in the construction of a new addition to its rolling mill at the foot of Park Avenue.

OAKLAND.—The Spencer-Kellog Company, Edgewater, N. J., is planning for the construction of a new linseed oil plant on a local site now under consideration. The works, which will be among the largest in the world, are estimated to cost $400,000.

SAN FRANCISCO.—The Pacific Gas & Electric Company is planning for extensive improvements and additions to its plant at Fresno. A portion of the work, which will cost about $400,000, has been commenced.

SAN FRANCISCO.—Announcement has been made that effective January 1, 1918, the Pacific Hardware & Steel Company and Baker & Hamilton will be merged into one corporation, to be known as the Baker, Hamilton & Pacific Company, capitalized at $4,250,000. Alexander Hamilton is president of the new company.

FILLMORE.—The Ventura Refining Company has completed the construction of its new local wax refinery, and operations have been inaugurated. The product of the new plant is in great demand for the making of explosives, paper boxes, etc.

KESWICK—The Mountain Copper Company is having plans prepared for the construction of a new addition to its oil flotation plant for the treatment of copper ore at the Minnesota station, between Keswick and Iron Mountain, to double the present capacity. When completed, the works will have an output of about 1,040 tons daily.

Colorado

CRIPPLE CREEK—The Vindicator Consolidated Gold Mining Company has completed improvements in its 600-ton flotation mill. At the present time the mill produces about 12 tons of concentrate daily, running from $25 to $30 per ton.

Connecticut

ANSONIA.—The American Brass Company has taken out a building permit for alterations and improvements in a two-story building, about 30 x 100 ft., now used for storage purposes, to provide for increased capacity.

NEWINGTON. — Construction is being rushed to completion on the new two-story paper mill being erected for Thomas F. Garvan. The structure is about 47 x 147 feet, and the installation of the necessary equipment has been commenced.

STAMFORD.—The American Synthetic Colors Company is planning for the construction of a large addition to its plant to provide for increased capacity. The structure is estimated to cost $30,000.

WATERBURY.—The Connecticut Brass & Manufacturing Company, which recently took over the Pilling Brass Company, is planning for the erection of a one-story addition to its plant to provide for increased capacity.

Delaware

NEWARK.—The plant of the Jacob Thomas Company, manufacturer of wall paper, was completely destroyed by fire on Jan. 11, with loss estimated at about $225,000. The destruction of the plant has thrown about 150 hands out of employment.

Georgia

CAMILLA.—The W. F. Cullens Fertilizer Company is planning for the erection of a large new addition to its plant, to provide for increased capacity.

Illinois

CHICAGO.—The Standard Steel Car Company has had plans prepared for the construction of a new one-story machine shop at its Hammond, Ind., works. The structure, which will be about 250 x 800 feet, is estimated to cost $200,000.

CHICAGO.—Rapid progress is being made by the William Glader Machine Works, North Ann Street, in the construction of a new three-story plant. The structure will be about 50 x 100 feet and cost $20,000.

Indiana

LOGANSPORT.—Fire, on January 8, destroyed a portion of the plant of the Logansport Casting Company, a section of the Western Motor Works, with entire loss estimated at $70,000. A. W. Pattu is manager.

MUNCIE.—The Eagle Foundry Company has filed plans for the construction of a new one-story addition, about 25 x 125 ft., on Willard Street. Contract has been awarded.

MUNCIE.—Fire on January 10 destroyed a portion of the plant of the Central Indiana Gas Company, Brotherton Street and Big Four Railroad, with loss estimated at $15,000. It is said the company will immediately rebuild.

Iowa

BURLINGTON.—The North Western Stamping Company has had plans prepared for the construction of a new one-story factory, about 100 x 300 feet, at its plant. A. J. Klein, Burlington, is the architect.

Louisiana

BOGALUSA.—Operations have been inaugurated in the new plant of the Bogalusa Paper Company, just completed, at a cost of $1,500,000. The plant will be operated largely on waste from the works of the Great Southern Lumber Company, situated near here.

SHREWSBURY.—The Planters' Fertilizer & Chemical Company, controlled by Armour & Company, Chicago, Ill., has just completed the erection of a large plant for the manufacture of boneblack. This is the first plant of its kind in the South, and the output, which is most universally used in the refining of sugar, will be utilized almost exclusively in this State.

BREAUX BRIDGE.—The Southern States Oil & Gas Company, Indianapolis, Ind., has acquired property on Banard Street, about 500 x 1000 ft., and is planning for the erection of a large new oil refinery. This location gives the company both water and rail facilities for transportation.

NEW ORLEANS.—The United Chemical & Organic Products Company, which recently acquired the local plant of the Hirsch-Stein Company of Chicago, has completed all building units in accordance with its original plans. The company will specialize in the production of commercial chemicals and bone products. An investment of approximately $500,000 is represented in the new construction, etc.

Maryland

BALTIMORE.—The Piedmont-Mt. Airy Guano Company has filed plans for the construction of a new fertilizer building to cost about $60,000. Contract for erection has been awarded.

BALTIMORE.—Fire recently destroyed a portion of the plant of the American Propeller Works, Light Street, with loss estimated at approximately $90,000. The company is considering plans for the immediate reconstruction of the destroyed section.

CURTIS BAY.—The Industrial Alcohol Company has awarded a contract to the Austin Company, Bulletin Building, Philadelphia, Pa., for the construction of three new two-story manufacturing buildings to cost about $100,000.

SPARROWS POINT.—The Bethlehem Steel Company will build new one-story addition to its plant, about 30 x 35 ft., and 35 x 60 ft.

Massachusetts

EVERETT.—The New England Oil, Paint & Varnish Company is making rapid progress in the construction of its new one-story factory addition, about 30 x 48 ft. The company is planning to complete the structure and commence the installation of machinery at an early date.

EAST CAMBRIDGE.—Fire recently destroyed the local car-building and repair shops of the Boston & Maine Railroad, including damages to the power house, roundhouse, machine shop and blacksmithing works. The entire loss is estimated to be approximately $150,000. It is said that the rebuilding will be commenced at once.

LOWELL.—The International Steel Company, Middlesex Street, has taken out a building permit for the construction of a new addition, about 20 x 100 feet, to its plant.

MARLBORO.—The Lapointe Machine Tool Company, Tower Street, is making rapid progress in the construction of a large new addition to its plant, to provide for increased capacity.

SPRINGFIELD.—The Springfield Aircraft Corporation has commenced the construction of a new addition to its plant to cost $50,000. Wyckoff & Lloyd, Springfield, are the contractors.

SPRINGFIELD.—The Fleming Foundry Company has filed plans for the construction of a new two-story addition, about 50 x 55 feet, to its foundry. Contract has been awarded to the W. A. Newton Company, Springfield.

WORCESTER.—The Worcester Glass Company has commenced operation in its new plant on May Street, to be devoted to the manufacture of French mirrors, bevel plates, automobile shields, etc.

Michigan

JACKSON.—Fire completely destroyed the plant of the Periman Rim Company, manufacturer of automobile rims, etc., recently, with loss estimated at approximately $80,000.

Minnesota

MINNEAPOLIS.—Fire recently completely destroyed the large plant of the Kausel Foundry Company, Dartmouth Street and Twenty-seventh Avenue, S. E. It is said the works will be rebuilt at once. John Kausel heads the company.

Missouri

KANSAS CITY.—The Sinclair Refining Company, Tulsa, Okla., has completed all plans for the construction of its new oil distributing station at Harrison Street and the Kansas City Railway Terminal. The new plant will comprise a large oil filling station, pump house, boiler room and locker room, one-story repair plant and garage, three-story and basement, barrel house, and administration building. The Leonard Engineering Company, McCormick Building, Chicago, Ill., is engineer and contractor.

ST. LOUIS.—The St. Louis Malleable Casting Company, Conduit Avenue, has completed all plans for the construction of a new plant to comprise a forge shop, machine shop, foundry, electric power plant, and auxiliary structures. The entire works, when completed, are estimated to cost about $400,000.

Montana

BAKER.—The Treasure State Gas & Oil Company, which was recently taken over by New York interests, is planning for the immediate installation of a large carbon plant on Cabin Creek, about twenty miles north of Baker. The company will also sink three more wells within the next few months for the purpose of procuring sufficient gas to supply the requirements of the carbon plant.

Nebraska

OMAHA.—The laboratory and administration building of the American Smelting & Refining Company was recently destroyed by fire, with loss estimated at approximately $25,000.

New Jersey

DOVER.—One of the comparatively new and permanent industries to be established and located in the Dover manufacturing district is the International High Speed Steel Company. Their plant is located along the Delaware, Lackawanna & Western Railroad, about two miles from the center of Dover. They manufacture hollow and solid rock drill steel, which is used chiefly for mining purposes. Before the declaration of war in Europe, hollow rock drill steel was not made in the United States, and at the present time the International High Speed Steel Company is the only concern in the United States that manufactures hollow steel. They now have orders sufficient to keep their plant in operation at capacity for the next two years. None of these orders are war orders. All current for power, lighting and electric furnaces is supplied by the New Jersey Power & Light Co.

EDGEWATER.—Spencer Kellog & Sons have filed plans for the construction of a new five-story addition to their oil manufacturing plant, about 30 x 50 feet. Contract for construction has been awarded to the John W. Ferguson Company, 152 Market Street, Paterson.

BLOOMFIELD.—Organization papers have been filed by the Mayland Manufacturing Company, notifying of intent to operate a chemical manufacturing works at 71 Willett Street. Anthony J. Mayland heads the company.

BOUND BROOK.—For the purpose of increasing its capacity, and for the completion of a large Government order, the Calco Chemical Company, Bound Brook Road, manufacturer of chemicals, has commenced the construction of a large new addition to its plant. Frank N. Goble, 1 East Forty-second Street, New York, has the contract for erection.

HOBOKEN.—Fire recently destroyed the plant of the Gatti-McQuade Company, manufacturer of mill supplies and paper, with loss estimated at approximately $250,000.

JERSEY CITY.—The Humphrey Mantle Company, formerly located, at Gloucester, has acquired a four-story factory building at 61-67 Bishop Street, and is planning to install equipment at once for the manufacture of gas mantles.

HARRISON.—The National Oil Products Company, Essex Street, is planning to greatly increase the capacity of its local plant, and has commenced the construction of several new additions for this purpose.

NEWARK. — The Butterworth - Judson Corporation, Avenue R, manufacturer of chemicals, has taken out a building permit for the construction of a new two-story addition to its plant, about 60 x 105 ft. The structure will cost $12,000.

NEWARK.—A new one-story brick condenser house addition, about 40 x 60 ft., will be erected at the chemical manufacturing plant of the Maas & Waldstein Company, Avenue R. The company has taken out a building permit for the structure.

KINGSLAND.—The Nitro Chemical Corporation, 20 Broad Street, New York, has recently acquired a portion of the local plant of the Canadian Car & Foundry Company, and is planning to commence immediate construction of about twenty-five new buildings, 60 x 400 ft., to be devoted to the manufacture of picric acid for the Government. When running to capacity, it is expected that the plant will have an output of approximately 800,000 pounds monthly of wet picric acid, which is used in the manufacture of hand grenades. About 4000 hands will be employed. Contract for the construction of the new plant has been awarded to W. J. Burke, Lyndhurst.

PERTH AMBOY.—Fire, on Jan. 12, destroyed a portion of the plant of the Roessler & Hasslacher Chemical Company, with loss estimated at about $25,000. The company has recently enoveyed to the General Bakelite Company, manufacturer of insulation specialties, a subsidiary organization, property at Fayette and Rector Streets. It is said that the site will be used for extensions to the latter company's plant.

TRENTON.—The Globe Rubber Tire Company is planning for the construction of additions and improvements at its plant to provide for increased capacity.

New York

NEW YORK.—The Andes Exploration & Smelting Corporation, 68 William Street, has filed notice of a change in its corporate name to the Andes Electric Corporation.

BROOKLYN.—Lehn & Fink, 39 Sedgwick Street, manufacturers of chemical compounds, etc., have had plans prepared for the construction of a new addition to its brick plant to cost about $60,000. Buchman & Kahn, 30 East Forty-second Street, are the architects.

BROOKLYN.—The Continental Varnish Company, Newark, N. J., has awarded a contract for the erection of its proposed new factory group to be located at Ingraham Street and Varick Avenue. The new works will include a one-story main building, 60 x 80 ft., varnish house and garage, mixer building, and auxiliary structures, the entire work to cost $25,000. The Amsel Construction Company, 927 Broadway, Brooklyn, is the contractor.

FARMINGDALE, L. I.—The Farmingdale Chemical Company, manufacturer of chemicals and allied products, has acquired the plant of the E. C. Nelson Manufacturing Company, Farmingdale, for a consideration of about $75 000, and is planning to operate the works for the manufacture of chemicals which were obtained from Germany before the war.

LONG ISLAND CITY.—The Akron Tire Company, Honeywell Street and Skillman Avenue, has had plans prepared for the construction of a new one-story brick addition, about 50 x 95 ft., to its plant. The structure will cost $12,000.

LONG ISLAND CITY.—The Van Iderstine Company, Railroad Avenue, manufacturer of soaps, etc., is planning for the immediate construction of a new six-story reinforced-concrete plant, about 90 x 120 ft., on Newtown Creek, to cost about $70,000.. Plans have been prepared.

LONG ISLAND CITY.—The Pittsburgh Plate Glass Company is planning for the erection of a large new plant, about 260 x 280 ft., to be located on Hunters Point Avenue. The works are estimated to cost $350,000, and plans are now in course of preparation.

LITTLE FALLS.—Fire recently damaged the plant of the Barnet Leather Company, East Mills Street, manufacturer of leather. The destroyed section will be immediately rebuilt.

JAMESTOWN.—The Curtis Machine Company, East Second Street, which was engaged in the manufacture of propellers for aeroplanes for the Government, was partially destroyed by fire recently, with loss estimated at $35,000.

BALLSTON SPA.—Fire recently destroyed a portion of the plant of the American Hide & Leather Company, which is engaged on United States Army contracts, with loss estimated at $35,000. The tannery will be immediately rebuilt.

North Carolina

ASHEVILLE.—Anson G. Betts & Company, operating a mine at Shut-in-Creek for the production of iron ore, has greatly increased its output since the entrance of the United States in the war, and is planning for further development work.

CHARLOTTE.—Fire recently destroyed the local plant of the Buckeye Cotton Oil Company, with loss estimated at $100,000. The main plant of the company, which is located on the outskirts of the city, was not damaged.

Ohio

CANTON.—The ten new steel mills constructed as an addition to the plant of the Berger Manufacturing Company at a cost of approximately $4,000,000 will be completed at an early date, and the company is planning to inaugurate operations. The new additions will increase the output of the plant from 100,000 tons a year to about 160,000 tons.

CASTALIA.—The Castalia Cement Company is seriously considering the construction of a large local plant to be devoted to the production of potash as a byproduct.

COLUMBUS.—Fire, on January 9, destroyed the local plant of the American Chain Company. The loss is estimated at $150,000. The plant was engaged in the manufacture of chains for the Government, and about 800 employes are thrown out of work.

MARION.—The Commercial Steel Castings Company, recently incorporated with a capital of $150,000 is planning for the immediate construction of a large plant to have a capacity of about 20 tons of finished castings daily. The new works will give employment to about 125 hands for initial operations.

YOUNGSTOWN.—The Liberty Steel Company, which is now constructing an eight-mill tinplate plant near Warren, is planning for the construction of four additional mills, making it a twelve-mill plant. The works were originally planned for the production of steel sheets, but the procedure was changed when the heavy demand for tin became apparent.

YOUNGSTOWN.—The Carnegie Steel Company has inaugurated operations at its new bar mill just completed. Three other mills are also in course of construction.

Oklahoma

OIL CITY.—The American Industrial Oil Company, Oklahoma City, has acquired the Kenthoma property consisting of about 90 acres, and is planning for the immediate construction of a new refinery. The company has awarded a contract to B. Stutsel, Oil City, for the drilling of thirty-five additional wells.

Pennsylvania

BRADFORD.—S. A. Mundy and associates have organized a new company with a capital of $3,500,000, and are planning for the erection of a large pulp mill to cost about $1,000,000 in southern Ontario. It is said the mill will provide employment for approximately 200 returned Canadian soldiers.

JOHNSTOWN.—Fire recently destroyed the benzol manufacturing plant of the Cambria Steel Company, with loss estimated at $30,000. The company will commence the rebuilding of the works at once.

NEWPORT.—The American Manganese Company is planning for improvements in its plant. Contract has been awarded for the relining of its local stack.

PHILADELPHIA.—The Thomas Potter Sons & Company, Second and Erie Avenues, manufacturers of linoleum, have had plans prepared for alterations in their plant.

PITTSBURGH.—The hammer shop and 21-inch mill at the Park plant of the Crucible Steel Company, Thirty-first and Smallman Streets, was destroyed by fire recently with loss estimated at about $30,000. The company will immediately rebuild.

SCRANTON.—The American Color Company, Coal Exchange Building, has taken bids for the construction of a new addition to its plant at Penn Avenue and Carbon Street, to cost $40,000.

TIONESTA.—Fire, due to an explosion, recently destroyed the plant of the Interior Oil & Gas Company, with loss estimated at $15,000.

South Carolina

FLORENCE.—The main seed house of the Southern Cotton Oil Company's plant, including machinery, equipment and 700 tons of cotton seed, was destroyed by fire recently, with loss estimated at $70,000.

Tennessee

HADLEY'S BEND.—The United States Government, War Department, is planning for the construction of a large new manufacturing plant to be devoted to the production of explosives at Hadley's Bend, near Nashville. When running to capacity, the plant is estimated to give employment to about 15,000 hands. The project will require an investment of approximately $60,000,000. Contract for construction has been awarded to the Thompson-Starrett Company, New York.

BON AIR.—The Bon Air Coal & Iron Corporation is progressing very rapidly with its development plans, and has just opened two new mines at Eastland and Bon Air. The company is planning to increase the output to about 2,000 tons daily. The coke ovens at Eastland are now being prepared for the manufacture of furnace coke to be supplied to the Allens Creek iron furnace. This company was recently organized with a capital of $10,000,000.

Texas

DALLAS.—The Texas Steel Company, which recently acquired the Rusk foundry property at Rusk, is planning to inaugurate operations at the plant within the next three months for the manufacture of pig iron and iron pipe. The company is also considering the erection of a large steel plant of 700 tons daily capacity at Beaumont.

ORLA.—The Standard Sulphur Company, Detroit, Mich., has acquired property near Orla on the Santa Fe Railway, and is planning for the construction of the initial unit of its plant, to have a capacity of 100 tons of refined sulphur daily. Estimated cost of the project is $75,000.

Utah

GUNNISON—The Gunnison Valley Sugar Company is making rapid progress in the construction of its large new plant, and it is expected that the works will be completed early in the spring. The cost of the new factory is said to be $500,000.

SALT LAKE CITY.—The Utah-Idaho Sugar Company, Vermont Building, has acquired property, about 93 acres, near Sunnyside, as a site for the construction of a large new sugar factory.

Virginia

HUNTINGTON.—The Virginian Potteries Company, recently organized, is planning for the construction of a new plant for the manufacture of pottery. The first unit of the works will be about 150 x 500 ft. W. H. Dunn is manager.

West Virginia

CLARKESBURG.—Fire recently destroyed a portion of the plant of the Norwood Glass Company, with loss estimated at $75,000, throwing about 300 hands out of employment. It is said that the plant will be immediately rebuilt. E. Hockstrosser is general manager.

CHARLESTON.—The United States Government has purchased about 1500 acres of land near Charleston, and is planning for the construction of a large plant for the manufacture of explosives, powder, etc., at a cost of $9,000,000.

Washington

LA GRANDE.—The American Nitrogen Products Company is planning for the installation of three new electric ovens, to provide for increased capacity. Contract has been awarded to the National Engineering & Equipment Company, L. C. Smith Building, Seattle.

Wisconsin

MENASHA.—The plant of the Wisconsin Rendering Company was recently destroyed by fire, with loss estimated at $10,000. The destroyed section will be rebuilt, it is said.